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AMERICAN ASSOCIATION

of

ECONOMIC ENTOMOLOGISTS

PROGRAM

Fiftieth Annual Meeting

Indianapolis, Ind.

December 27–31, 1937

Fiftieth Annual Meeting of the American Association of Economic Entomologists

Indianapolis, Ind., December 27–31, 1937

All sessions of the annual meeting will be held in the Lincoln Hotel, which is the Association headquarters.

The Entomological Society of America will hold its meetings on the same floor of the Lincoln Hotel on December 28 and 29.

The public address of The Entomological Society of America will be the feature of the Entomologists' Dinner to be held on Wednesday night at 6:30 p.m. Professor P. J. Parrott will be the speaker.

Exhibits will be staged in Parlors D, E and F. Meetings of the entomologists will be held in the Travertine room; The Entomological Society will meet in the Lincoln room.

The Plant Quarantine Section will be held in the Lincoln room on Thursday. Other conferences will be held as designated in the program, or the place of meeting will be announced.

[*Any author who is expected to take part in the annual program, but who finds that he is unable to present his paper or have it presented, should notify the Secretary, Dr. E. N. Cory, at once.*]

PROGRAM

W. P. FLINT, Chairman of Program Committee

Monday, December 27

1:30 p.m. Codling Moth Conference. B. A. PORTER, Chairman, Lincoln Room.

7:00 p.m. Tobacco Insect Council. W. D. REED, Chairman. Lincoln Room.

8:00 p.m. Executive Committee meeting.

8:00 p.m. Reception for President of the American Association for the Advancement of Science following address of retiring President, DR. E. G. CONKLIN.

Tuesday, December 28

SECTION OF APICULTURE

9:30 a.m., Travertine Room

EDWIN J. ANDERSON, Chairman W. A. PRICE, Secretary

Appointment of Committees on Resolutions and Nominations

Address of the Chairman. A Review of Beekeeping Conditions. EDWIN J. ANDERSON, State College, Pa.

1. Future Developments in Equipment for Heating and Bottling Honey. EDWIN J. ANDERSON, State College, Pa.

2. Environmental Factors and Size Variations in Honeybee Appendages. S. E. MCGREGOR, Washington, D. C.

3. Effect of Subzero Temperatures on Queenbees. WILLIAM C. ROBERTS, Washington, D. C.

4. Further Studies of Wintering Bees in North Carolina. F. B. MEACHAM, Raleigh, N. C.

5. Growth and Development of the Female Bee. R. M. MELAMPY, E. R. WILLIS and S. E. MCGREGOR, Washington, D. C.

6. Chemical Composition and Vitamin Content of Royal Jelly. R. M. MELAMPY and D. B. JONES, Washington, D. C.

7. Observations on the Resistance of Honeybees to European Foulbrood, C. E. BURNSIDE, Washington, D. C.

8. Relationship between the Number of Inspections and Occurrence of American Foulbrood in Texas. F. L. THOMAS and C. E. HEARD, College Station, Tex.

9. Results of Survey to Determine Losses among Bees Due to Cotton Dusting Operations. F. L. THOMAS, C. E. HEARD and C. J. BURGIN, College Station, Tex.

10. Vitamin Content of Bee Foods. I. Vitamin E Content of Royal Jelly and Bee Bread. M. H. HAYDAK and L. C. PALMER, St. Paul Minn.

11. Maryland Extension Schools in Bee Culture. GEORGE J. ABRAMS, College Park, Md.

12. Collecting Red Clover Pollen by Honeybees. (3 min.) W. E. DUNHAM, Ohio Experiment Station and U. S. Department of Agriculture.

13. Extent of Pollinating Activities on Red Clover by a Colony of Honeybees. (4 min.) W. E. DUNHAM, Ohio Experiment Station and U. S. Department of Agriculture.

PEA APHID CONFERENCE

W. P. FLINT, Chairman

10 a.m. (Room to be announced)

DISCUSSION

Pea Aphid Control Experiments
- in Illinois. W. P. FLINT and L. H. SHROPSHIRE
- in Maryland. ERNEST N. CORY and C. GRAHAM
- in Michigan. RAY HUTSON
- in New Jersey. T. J. HEADLEE and B. B. PEPPER
- in New York. P. J. PARROTT and HUGH GLASGOW
- in Wisconsin. J. E. DUDLEY and T. E. BRONSON

General Observations on Pea Aphid Control Measures for 1937. W. H. WHITE and NEALE F. HOWARD.

GENERAL SESSION

12 noon, Travertine Room

Call to Order by the President.

Appointment of Committees on Resolutions and Nominations.

Report of Committee on Constitution and By-Laws.

Presidential Address. The Relation of Entomology to Conservation. F. C. BISHOPP, Washington, D. C.

2:30 p.m., Travertine Room

Joint Session with The Entomological Society of America. Symposium on The Relationship between Insects and Plant Diseases. O. A. JOHANNSEN, presiding.

1. Insects in Relation to Diseases of Truck Crops. A. A. GRANOVSKY, St. Paul, Minn.

   Discussion Leader, D. M. DELONG, Columbus, Ohio.

2. Insects in Relation to Diseases of Fruit Trees and Small Fruits. L. O. KUNKEL, Princeton, N. J.

   Discussion Leader, E. M. SEARLS, Madison, Wis.

3. Insects in Relation to Diseases of Shade and Forest Trees (Film on Bark Beetle Blue Stain). J. G. LEACH, St. Paul, Minn.

4. Insects in Relation to Diseases of Cereal and Forage Crops. F. W. POOS, Rosslyn, Va.

   Discussion Leader, J. W. INGRAM, Houma, La.

5. Problems Involved in Control of Plant Diseases and Insects. N. E. STEVENS, Urbana, Ill.

SECTION OF EXTENSION

8 p.m., Travertine Room

T. H. PARKS, Chairman — L. H. SHROPSHIRE, Secretary

Symposium on Agencies for Extending Entomological Information

1. *Commercial and Agricultural.* T. H. PARKS, S. C. MCCAMPBELL.
2. *Press.* C. B. DIBBLE, G. C. DECKER.
3. *Bulletins and Circulars.* R. W. LEIBY, GEO. D. JONES.
4. *Radio.* W. P. FLINT, H. L. PARTEN.

5. *Visual Instruction.* G. E. LEHKER, R. R. REPPERT, H. E. HODGKISS.

6. *Demonstrations.* W. C. NETTLES.

7. *Can We Adopt Uniform Methods for Measuring Results in Entomological Practice?* M. P. JONES.

Election of Officers

Adjournment

EXECUTIVE COMMITTEE

8 p.m.

Presentation of committee reports except those which are scheduled for the final business session.

Wednesday, December 29

GENERAL SESSION

9:30 a.m., Travertine Room

Reports of Executive Committee and Secretary.

Report of the Nominating Committee on Nominees to Standing Committees.

Election of Nominees.

1. Biological Disposition of Rotenone after Ingestion by the Southern Army worm. P. A. WOKE, Beltsville, Md. (By title only.)

2. Hibernation of the Cotton Bollworm, *Heliothis obsoleta* (Fabr.) (12 min.) R. K. FLETCHER, College Station, Tex.

Spring emergence of moths from and the winter survival of pupae in several different soils under different conditions of drainage.

3. Comparative Resistance of Different Varieties of Sweet Corn to Injury by the Corn Earworm at Norfolk, Va. (10 min., lantern.) HARRY G. WALKER and LAUREN D. ANDERSON, Norfolk, Va.

More than 50 varieties of sweet corn have been tested for earworm at Norfolk, Va., during the last four years. Such varieties as Honey June, Surcropper Sugar, Texas Evergreen, Early Snowflake, Redgreen Hybrid, Georgia Early and Late, Truckers Favorite, and Norfolk Market were quite resistant, while other varieties such as Spanish Gold, Golden Early Market, Early Surprise, and Golden Sunshine were very susceptible to injury by this pest.

4. Studies in Grasshopper Increase. (5 min., lantern.) LEONARD HASEMAN, Columbia, Mo.

Since 1935 there has been each year a definite building up of populations of four destructive species, *M. mexicanus, femur-rubrum, differentialis* and *bilineata.*

5. Peanut Pouts. (5 min. lantern.) Z. P. METCALF, Raleigh, N. C.

A discussion of the importance of the bean leafhopper as a pest of peanuts.

6. Two major pests of Cotton in Pernambuco, Brazil. (15 min., lantern.) LOUIS PYENSON, Ithaca, N. Y.

Larvae of *Gasterocercodes gossypii* Pierce burrow in the cambium and xylem of the cotton roots, weaken the plants and cause the death of many before they bear a crop.

Adults of *Chalcodermus bondari* Marshall make a ring of punctures around growing tips, flowers stems and the leaf petioles of the cotton plants. This injury severely stunts the plant's growth and kills young seedlings.

7. Infestation of *Aegilops* spp. and *Aegilops*–Wheat Hybrids by the Hessian Fly. (5 min.) ELMER T. JONES, Manhattan, Kans.

The reaction to Hessian fly infestation of 11 species of *Aegilops* and 12 *Aegilops*–wheat hybrid selections is discussed. Most species and selections are susceptible, but a few are highly resistant to the Hessian fly. These susceptible grasses are important potential hosts of the fly.

8. Comparative Resistance to the European Corn Borer of Two Hybrid Strains of Field Corn at Toledo, Ohio. (10 min.) L. H. PATCH, Toledo, Ohio.

Field experiments carried on in 1936 and 1937 under the direction of the laboratory at Toledo, Ohio, included the top-crossed hybrid field corn strain Mich. No. 561. This strain has been reported to be resistant to the European corn borer. In comparison with standard strains of about equal season requirements known to possess no inherent resistance to the corn borer, and tested by proven methods of inducing infestations by hand, Mich. No. 561 was found not to be relatively borer resistant with respect to the number of mature borers surviving from a given number of eggs. In other experiments Mich. No. 561 was found not to be borer resistant with respect to the deposition of eggs by the moths in nature, nor to the reduction in the yield of grain by a given number of borers compared with the reduction expected of strains of equal yielding capacity.

9. Effects of Certain Insecticides on *Phyllophaga hirticula* (Knoch) (Coleop. Scarabaeidae). (5 min.) C. L. FLUKE, T. R. CHAMBERLIN and LEE SEATON, Madison, Wis.

Acid lead arsenate or the proprietary coated lead arsenates are more effective in killing the bettles than certain other arsenicals. Males died more readily than females. Arsenicals stimulated oviposition, while check cages delayed it. Less amounts of foliage were eaten when sprayed with lead arsenates than when treated with any other material.

10. Annual White Grub, *Ochrosidia villosa* (Burm.), in Ohio Lawns. (10 min., lantern.) C. R. NEISWANDER, Wooster, Ohio.

For the last three years the annual white grub has been found to be particularly abundant and destructive to lawns over the eastern half of Ohio. This paper deals with the relative distribution of the species within the state, its economic importance, and the methods of control that have been tested.

11. Observations on the Horizontal Distances Travelled by *Melanotus* larvae (Elateridae). HARRY R. BRYSON and FRED S. KRUGER, Manhattan, Kans. (By title only.)

Field and insectary studies of wireworms to determine the rapidity with which they disperse from a given center show that larvae of the genus *Melanotus* were slow to migrate from a center of dispersal. The observations indicate that the larvae travelled no farther than necessary to find food and the search consisted largely of random movements.

12. Field Status of European Corn Borer Parasites at the Close of 1936. (10 min.) W. A. BAKER and W. G. BRADLEY, Toledo, Ohio.

A summary of the status of parasites of the European corn borer in the United States as reflected by percentage of parasitization at selected liberation localities.

13. Status of the European Corn Borer in 1937. (10 min.) W. A. BAKER and A. M. VANCE, Toledo, Ohio.

Résumé of the known distribution of the European corn borer in the United States, and discussion of its abundance in 1937 as determined from surveys of corn and potato fields.

14. Serious Outbreak of the Tobacco Flea Beetle, *Epitrix parvula* Fab., in Virginia. (5 min., lantern.) W. J. SCHOENE, Blacksburg, Va.

The tobacco flea beetle occurred in uausual numbers in a restricted area in the state. Principal damage occurred at transplanting time. Leaves of many plants were consumed and large numbers of larvae occurred on the roots. In addition to flea beetles the disease blue mold was also present.

1:30 p.m., Travertine Room

15. The Literature of American Economic Entomology. (15 min.) E. P. FELT, Stamford, Conn.

A discussion of the development, importance and trends of our current literature.

16. Terms: Brood and Generation. (5 min.) J. A. HYSLOP, Washington, D. C.

Object of this paper: Presented with the hope that it will lead to a fruitful discussion that may eventually result in the Association's adopting definitions for these two terms.

17. Temperature and Codling Moth Oviposition. (8 min., lantern.) DWIGHT ISELY, Fayetteville, Ark.

Presentation of data showing the effect of temperature, particularly in summer, on oviposition by the codling moth.

18. The Kind of Light Most Attractive to Codling Moth. (10 min.) G. EDW. MARSHALL, Orleans, Ind.

For the last four years field and laboratory light tests have been conducted for the purpose of finding the kind of light that is the most attractive to the codling moth. The 1937 field work has been a study of the intensities using 1000-hour 100-watt lamps, the resistance modifications of which have produced lamps which would have 25, 100, 500 and 1000-hour lives respectively. Such modifications changed the spectral distribution. In the laboratory work many different kinds of lights were used, some of which were new, having been prepared especially with these tests in mind. These laboratory tests were conducted using constant voltage, controlled identical and measured lamp output in lumens, newly emerged codling moth adults, a knowledge of the spectral distribution of the lamps used, and the elimination or inclusion of certain spectral bands when desired.

The results of these field and laboratory tests may be concluded as follows: The principles of most importance in the attractiveness of lights to the codling moth are (a) intrinsic brilliancy; (b) the size of the luminous body; (c) the color of the light.

19. Comparison of Tank-mix Nicotine–Bentonite–Soybean Oil and Lead Arsenate Sprays for Control of Codling Moth. (15 min., lantern.) L. F. STEINER and R. F. SAZAMA, Vincennes, Ind.

A tank-mix combination of nicotine sulfate, bentonite, soybean oil and sodium lauryl sulfate provided control of codling moth equal or superior to that obtained

by the lead arsenate schedule. Field tests in 1937 involved its use on more than 100 acres with three orchards and six varieties represented. The combination has been outstanding for four years among numerous fixed-nicotine and other preparations tested with laboratory and field-sprayed fruit to which more than a million newly hatched larvae have been applied

20. Comparative Tests of Fixed Nicotines and Lead Arsenate against Codling Moth. (5 min.) RAY HUTSON, J. M. MERRITT and FRANK PARMELEE, East Lansing, Mich.

Comparative randomized replicate tests of various fixed nicotine combinations, with and without oil and lead arsenate, in a heavily infested orchard reveal that fixed nicotine combinations gave field control of codling moth under the experimental conditions without the necessity of washing.

The effectiveness of the various nicotine combinations is considered in the light of differences in timing, adjuvants, larval injury and foliage, foliage tolerance and fruit resulting from the sprays.

Results of commercial application of one of the more promising nicotine combinations is presented in confirmation of the plot tests.

21. Recommendations for Control of Plum Curculio on Peach. (5 min.) S. C. CHANDLER, Carbondale, Ill.

Apparent inconsistencies and wide differences exist in recommendations and practices for control of plum curculio in peach areas east of the Mississippi river. A report of conditions found and reasons for recommendations in several states is given.

22. Nine Years Work with Oil Dust for Oriental Fruit Moth Control. (6 min., lantern.) W. P. FLINT, S. C. CHANDLER and M. D. FARRAR, Urbana, Ill.

When the oriental fruit moth was first established in Illinois it became apparent that a new insecticide was necessary to obtain control. A number of combinations were tried. Among these the use of dusts in which small amounts of mineral oil had been very thoroughly mixed. The first year that these were used favorable results were obtained. We have now carried on tests with this type of material for nine years and the results show that where the dusts were properly made and applied they may be depended upon to give a practical commercial control for the oriental fruit moth.

23. Strawberry Leaf Roller, *Ancylis comptana* Froel., in Ohio. (7 min., lantern.) R. B. NEISWANDER, Wooster, Ohio.

During recent years the strawberry leaf roller has caused severe damage in certain localities in Ohio. Biological studies have shown two complete generations and a partial third each season. The larval parasites, *Cremastus cookii* Weed and *Macrocentrus ancylivorus* Roh., are well established in Ohio, but as yet have parasitized only a small percentage of the leaf roller larvae.

Extensive field experiments have shown cryolite, used either as a dust or a spray, to be effective in reducing leaf roller damage.

24. Method for Recording Effects of Dormant Sprays upon Apple Tree Growth. (5 min., lantern.) JOHN H. LILLY, Madison, Wis.

Description of a method devised to measure both favorable and unfavorable effects of dormant oil sprays upon leaf development and growth in apple trees.

25. Value of Coal-tar Distillates in Dormant and Delayed-dormant Sprays. (15 min., lantern.) JOSEPH M. GINSBURG, New Brunswick, N. J.

In this paper, laboratory and field experiments with different coal tar distillates, conducted over a period of several years, are briefly described. The results definitely indicate that emulsions of neutral, high-boiling tar oils can be

safely used as dormant sprays to control aphids on apple trees. Practically no differences were observed between home-made and commercial emulsions.

26. Simuliids Found Feeding on Turkeys in Virginia. (5 min., lantern.) G. W. UNDERHILL, Blacksburg, Va.

In connection with a study on insect transmission of a blood protozoan disease in turkeys, two species of simuliids have been found to feed readily on turkeys in the field. This paper includes the distribution and seasonal occurrence of the insects, the types of streams in which the larvae are found, and a brief discussion of the habits of the flies. Short descriptions and drawings showing the chief morphological characters are included.

27. Progress to Date in Studies of Radio Waves and Related Forms of Energy for Insect Control. (15 min., lantern.) THOMAS J. HEADLEE and DANIEL M. JOBBINS, New Brunswick, N. J.

Heat appears to be the lethal agency. Heat is developed throughout the mass simultaneously in a homogeneous body subjected to the electrostatic field, but in a heterogeneous body focal points of greater heat frequently occur. Mass materials subjected to either infra-red or ultra-violet show heating in the outer layers first and heating of the inner by conduction.

28. Motion Picture of Life Stages and Habits of the White-fringed Beetle, *Naupactus leucoloma* Boh., and Control Activities against It. (25 min., projector furnished by narrator.) H. C. YOUNG, Floral, Ala.

This picture shows the life stages, damage and activities of the beetle, and the control measures employed to suppress it.

ENTOMOLOGISTS' DINNER

6:30 p.m., Travertine Room

Public Address of The Entomological Society of America. PROFESSOR P. J. PARROTT, Geneva, N. Y.

Thursday, December 30

GENERAL SESSION

9:30 a.m., Travertine Room

29. Evaluating Derris and Cubé. The Question of Total Extractive Content. (10 min., lantern.) HOWARD A. JONES and W. N. SULLIVAN, Beltsville, Md.

The total extractive content of derris and cubé roots is now determined in a wide variety of solvents by various laboratories. The purpose of the present work was to decide on the solvent and method which would most readily extract all the toxic substances with the least amount of nontoxic material. Tests were made against mosquito larvae of acetone extracts of the marcs from chloroform, benzene and ether extractions of root samples. Marcs from ether and benzene were appreciably toxic. Marcs from chloroform were in general nontoxic. It is suggested that the simplest procedure for obtaining the total extractive content, and one which gives an accurate measure of the toxic material, is a determination made on an aliquot of a room temperature chloroform extract of the root.

30. Laboratory Tests with Derris and Oil Against Plant Bugs. (12

min., lantern.) ROBERT A. FULTON and NEALE F. HOWARD, Columbus, Ohio.

Certain vegetable oils when emulsified and used with water suspensions of powdered derris resulted in a marked increase in toxicity to the milkweed bug and the squash bug. Technic used to apply measured doses to individual insects is described. Comparison is made of the toxicity of derris with a few other insecticides.

31. Quantitative Toxicities of Some Typical Contact Insecticides. (15 min., lantern.) W. A. SIMANTON, Pittsburgh, Pa.

This paper presents the results of a laboratory study in which five types of contact insecticides were tested against three widely different species of insects. In addition to the relative toxicities, quantitative toxicities were calculated from determinations of the actual amounts of poison contacting the insects Mortality relationships were expressed on three bases: as concentration of insecticide in the spray solution, as milligrams of insecticide per gram of body weight, and as milligrams of insecticide per square centimeter of body surface. The data summarized in graphs and tables indicate that all three bases have an effect on the mortality exhibited. In general, the toxicity is better evaluated as milligrams of insecticide per gram of body weight. Some observations on the action of contact insecticides are also included.

32. Effect of Repeated Applications of a Pyrethrum Spray on a Housefly Population. (10 min., lantern.) A. C. MILLER, Pittsburgh, Pa.

A series of tests was conducted in which a given group of houseflies were sprayed at daily intervals with a naphtha base pyrethrum fly spray. Experimental groups received an average of seven treatments. Such a series of repeated applications effects the selection of a small group of females exhibiting slight susceptibility to the action of the pyrethrum spray. Females receiving as many as 10 sublethal dosages of pyrethrum, in amounts sufficient to cause paralysis at each treatment, continued to lay fertile eggs and retained apparently normal behavior.

Groups of flies which had recovered from paralysis caused by a single treatment showed no marked difference when compared with untreated check groups on the basis of longevity, fecundity, and fertility.

33. Experiences with Mothproofing Solutions. (15 min., lantern.) E. A. BACK, Washington, D. C., and R. T. COTTON, Manhattan, Kans.

General discussion of experiences.

34. Insulation and Household Insects. (15 min., lantern.) E. A. BACK, Washington, D. C.

Observations in infested houses and tests with mineral wool.

35. Methods and Equipment for Laboratory Studies of Insecticides. II. (15 min., lantern.) HAROLD WATERS, Columbus, Ohio.

The study of methods and equipment for laboratory rearing of insects for insecticide tests has been continued. Cages that simplify the rearing of many species of insects, and methods for laboratory rearing of several economic insects for test purposes have been developed. Methods and equipment for applying insecticides to foliage in predetermined quantities, both as sprays and dusts, are described.

36. Particle Size of Commercial Insecticidal Sulfurs by Sedimentation Analysis. (10 min., lantern.) LYLE D. GOODHUE, Beltsville, Md.

The particle size distribution in 44 samples of commercial insecticidal sulfur has been determined by sedimentation analysis. A new method of dispersion using a wetting agent composed of a mixture of saponin and ammonium caseinate in ammoniacal 50 per cent alcohol was found to give very good results on a wide

variety of samples. The flotation pastes and suspensions of colloidal sulfur were found to contain the most fine material. A material made by spraying molten sulfur ranks next. Except for two coarsely ground crude samples the ground sulfurs fall in about a medium fine class. The sublimed flowers are variable and may be either fine or coarse. The amount through 325 mesh was found to give very little indication of the amount of very fine sulfur in a sample.

37. Rapid Method of Evaluating Livestock Sprays. (15 min., lantern.) CRAIG EAGLESON, Dallas, Tex.

The method consists of spraying insects confined in revolving screen-wire cages in a wind tunnel where fumigatory effect is at a minimum, then placing them in a ventilated recovery cabinet for observation. Relative susceptibilities are given of stable flies, horn flies and houseflies to pyrethrum sprays.

38. Estimate of the Dosage-mortality Curve from Small Samples. (15 min., lantern.) C. L. BLISS, Leningrad, U.S.S.R.

When a poison must be administered to organisms individually, it may be impracticable to use large numbers or to control each dose precisely. This is frequently true in laboratory experiments on stomach insecticides. A method is proposed whereby the dosage-mortality curve can be estimated from such data with a measureable degree of precision.

39. Measuring the Joint Action of Two or More Poisons. (15 min., lantern.) C. L. BLISS, Leningrad, U.S.S.R.

A uniform procedure is proposed for analysis of toxicological data involving two or more toxic components, based upon dosage-mortality curves determined from each of several mixtures of the ingredients. Results of the calculations can be reduced to a curve showing the dosage of the combined insecticide which will produce a given mortality when its percentage composition is altered. The method is applied to data from recent literature.

40. Effects of Atmospheric Conditions upon Rotenones Exposed on Bean Plants, as Determined by Toxicity to the Mexican Bean Beetle. (10 min.) J. N. TODD, Clemson, S. C.

Results of one season's tests indicate that rotenone loses most of its effectiveness when exposed longer than five days under field conditions; whereas shaded from the direct rays of the sun the effectiveness is prolonged more than two weeks.

41. Conditioning Agents Increase the Effectiveness of Rotenone-bearing Dusts against the Pea Aphid. (8 min.) T. E. BRONSON and J. E. DUDLEY JR., Madison, Wis.

In both the greenhouse and the field, derris or cubé dust mixtures conditioned with a spreading and wetting agent have been shown to be superior, as an insecticide against the pea aphid, to plain derris or cubé dust mixtures. Under field conditions this superiority of the conditioned dust mixtures has amounted to approximately 12 per cent, which may be the difference between satisfactory and unsatisfactory aphid control.

In general, conditioned derris or cubé dust mixtures reinforced by the addition of nicotine or an aliphatic thiocyanate, when tested both in the greenhouse and in the field, have been superior to conditioned dust mixtures. This has been especially true in instances where the aliphatic thiocyanate was added.

42. New Facts Concerning Cryolite Spray Residues. (12 min.) S. MARCOVITCH and W. W. STANLEY, Knoxville, Tenn.

The experimental work with cryolite spray residues shows that they are of no public health significance. Dissolved fluorine in water supplies is capable of producing mottled enamel which is classed as a water-borne disease. More water is

used in cooking than in drinking. A sample of teakettle scale yielded 8072 parts per million of fluorine. On a weight basis, sprayed food constitutes less than 3 per cent of the amount of water consumed in drinking and cooking. Marine foods, such as sardines, and many baby foods show that they contain up to 12 parts per million of fluorine.

The data leads to the conclusion that in cryolite we have the long-sought-for arsenical substitute, a material that is incapable of causing fatalities and reasonably safe to human health.

43. Soybean Flour as a Spray Material. (5 min.) M. D. FARRAR and W. P. FLINT, Urbana, Ill.

Certain proteins of soybean flour make this product useful with insecticidal sprays. The flour disperses easily and causes a spray to wet, spread and adhere. It is neutral chemically and mixes easily with all common insecticides and fungicides. Amounts of flour required will depend to a very limited extent on water hardness. From one-eighth to one pound of flour per 100 gallons of spray mixture has given good results. That the grower has found this product useful is exemplified by the fact that in 1937 one Illinois soybean processor sold 60 tons of soybean flour for orchard spraying.

1:30 p.m., Travertine Room

44. Laboratory Studies on the Toxicity of Nicotine as a Fumigant for Various Insects, Including Aphids, Thrips and White Flies. (10 min., lantern.) HENRY H. RICHARDSON, Beltsville, Md.

A study was made of the efficiency of nicotine gas under laboratory conditions against various insects, including aphids, thrips and white flies. The different insects were found to vary greatly in their susceptibility to nicotine. The relationship of length of exposure and concentration of gas was investigated to some extent and these factors will be discussed.

45. Tandem Fumigation with Cyanogas for Control of Thrips in Greenhouses. (5 min.) W. E. MCCAULEY, Urbana, Ill.

Tandem applications of *Cyanogas "G" Fumigant* for control of *Thrips nigropilosus* increased the per cent of control without a proportionate increase of cyanide injury to Heliotrope and Chrysanthemum.

46. Development of Resistance to Hydrocyanic Acid on Certain Scale Insects. (10 min., lantern.) H. J. QUAYLE, Riverside, Calif.

An attempt is made to show that in the case of three different insects there has developed a marked difference in tolerance in different localities to the same insecticide. The question has an important bearing on the broad subject of the use of insecticides.

47. Fumigation of Insects with Hydrocyanic Acid: Effect of Different Air Pressures. (15 min., lantern.) WILLIAM MOORE and E. L. CARPENTER, Stamford, Conn.

The mortality obtained by fumigating with HCN at different air pressures and the relation of this mortality to the absorption of the HCN by the insects.

48. Laboratory Studies of Methyl Bromide as a Fumigant. (10 min., lantern.) F. FISK and H. H. SHEPARD, St. Paul, Minn.

The relative toxicity of methyl bromide to certain stored product insects has been shown to be high, comparing favorably with the most toxic fumigants in this respect. Temperature and moisture relations have been studied, and relative absorption values determined for flour, wheat and raisins. Baking and germination tests are reported.

49. Methyl Bromide, Its Expectancy as a Fumigant. (15 min.) D. B. MACKIE, Sacramento, Calif.

This paper deals with the future of methyl bromide as a fumigant. The conclusions are drawn from two years' experience in the application of this compound to the solution of a number of perplexing problems in the field of applied entomology. Much of the work has been done in the so-called regulatory field where the treatment, to be acceptable, must be 100 per cent lethal to the pest under consideration. The scope of these investigations covers a wide field of species and commodities. One paragraph deals with its particular chemical and physical properties; another with its effects on human beings.

50. Potato Spraying Experiments in North Dakota. (7 min.) J. A. MUNRO and LOUIS A. SCHIFINO, Fargo, N. D.

Increases in yields of potatoes with Bordeaux sprays that cannot be wholly attributed to the control of the potato leafhopper, *Empoasca fabae* Harris, or the potato flea beetle, *Epitrix cucumeris* Harris, are noted. Results of one season's work.

51. Preliminary Studies of Wireworms Affecting Potato Tubers in North Dakota. (4 min.) J. A. MUNRO and LOUIS A. SCHIFINO, Fargo, N. D.

Results of a wireworm injury survey are presented. Species of wireworms that are involved in tuber injury are listed.

52. Preliminary Report on Conditioned Resistance of Normally Susceptible Canning Peas to the Pea Aphis, *Illinoia pisi* Kalt. (5 min.) EDWARD M. SEARLS, Madison, Wis.

These studies indicate that susceptible varieties of canning peas become resistant as they approach maturity.

53. Control Experiments on the Tomato Fruitworm for the 1937 Season. (10 min.) JOSEPH WILCOX, Alhambra, Calif.

Results are given of several hundred field tests conducted in different localities in southern California on early market, canning and late market tomatoes.

54. Some Factors Influencing the Development of an Infestation by the Cotton Bollworm. (7 min.) F. L. THOMAS, R. K. FLETCHER, S. W. BROMLEY and H. B. PARKS, College Station, Tex.

Detailed observations have shown that the egg stage and first two instars of the bollworm are destroyed by a number of physical and biological factors which affect natural control to a considerable degree.

55. Onion Thrips Control. (10 min., lantern.) NEELY TURNER and G. L. WALKER, New Haven, Conn.

This paper gives results of successful applications of derris and cubé with suitable spreaders to control the onion thrips, *Thrips tabaci* Lind.

56. Results of Tests of Certain Materials as Controls for the Tomato Psyllid, *Paratrioza cockerelli* Sulc, and Psyllid Yellows. (12 min.) GEORGE M. LIST, Fort Collins, Colo.

Lime sulfur has become the standard control for the tomato psyllid, *Paratrioza cockerelli* Sulc, on potatoes. It often causes severe injury when used on tomatoes.

Field tests herein reported indicate that dusting sulfur and wettable sulfur are equally effective in destroying the psyllids on tomatoes and do not cause noticeable injury to the plants. The conclusions are based on psyllid counts, plant growth measurements, and yield in pounds, numbers and size of fruits.

57. Two Years Study of the Effects of Root Nematodes on the Yield of Canning Tomatoes. (15 min.) F. A. FICHT, Lafayette, Ind.

The reduction in the yield of tomatoes of canning grades and the decrease in the per acre market value of tomatoes from root nematode-infested plants is shown. The reduction in the number of fruits set, the effect of nematodes on ripening and the decrease in the size of fruits from infested plants is discussed. The comparison is between nematode-free and nematode-infested plants grown in the south and shipped into Indiana.

SECTION OF PLANT QUARANTINE AND INSPECTION

9:30 a.m., Lincoln Room

A. G. RUGGLES, Chairman E. L. CHAMBERS, Secretary

Appointment of Committees on Resolutions and on Nominations

1. Activities and Accomplishments of the Bureau of Entomology and Plant Quarantine, LEE A. STRONG, Washington, D. C.

2. Grasshopper Outbreak in Iowa. C. J. DRAKE and G. C. DECKER, Ames, Iowa.

3. Gypsy Moth and Browntail Moth Control Operations During 1937. A. F. BURGESS, Greenfield, Mass.

4. Recent Developments Relating to Transit Inspection, Phony Peach and Peach Mosaic Diseases and White-fringed Beetle Activities. B. M. GADDIS, Washington, D. C.

1:30 p.m., Lincoln Room

5. Present Status of the Japanese Beetle Situation in St. Louis. J. CARL DAWSON, Jefferson City, Mo.

6. Present Status of Barberry Eradication and White Pine Blister Rust Control. S. B. FRACKER, Washington, D. C.

7. Highlights of Foreign Plant Quarantine Enforcement and Export Certification, 1936–37. E. R. SASSCER, Washington, D. C.

8. South African Insects of Plant Quarantine Interest. GEO. C. BECKER, Washington, D. C.

9. Present Status of the Azalea Flower Spot Investigations. FREEMAN A. WEISS and FLOYD F. SMITH, Beltsville, Md.

Report of the National Plant Board, M. S. YEOMANS, Chairman, Atlanta, Ga.

Reports of the Regional Boards.

The Eastern Plant Board. E. N. CORY, Secretary, College Park, Md.

The Central Plant Board, P. T. ULMAN, Secretary, Indianapolis, Ind.

The Southern Plant Board, J. H. MONTGOMERY, Secretary, Gainesville, Fla.

The Western Plant Board, A. C. FLEURY, Sec'y-Treas., Sacramento, Calif.

Report of Resolutions Committee.
Report of Nominating Committee.
Selection of Officers.
Adjournment.

Friday, December 31

GENERAL SESSION

9:30 a.m., Travertine Room

58. Notes on the European Pine Shoot Moth in Connecticut. (15 min., lantern.) R. B. FRIEND, G. H. PLUMB and H. W. HICOCK, New Haven, Conn.

The distribution of the insect in the state, the intensity of the infestation and its relation to injury to red pine, the control work carried out, and some natural factors affecting abundance of the insect, are discussed.

59. Studies on Control of Cankerworms Infesting Forested Areas by Insecticides Applied by Autogiro. (15 min., lantern.) CLYDE C. HAMILTON, New Brunswick, N. J.

Studies were made to compare the effectiveness of sprays consisting of standard powdered arsenate of lead, a special dispersed arsenate of lead paste, a colloidal arsenate of lead, two arsenate of lead dust mixtures, and a calcium arsenate spray. The data indicate that cankerworms may be effectively controlled with most of the mixtures used; that the quantity of arsenical poison may be considerably reduced when applied by autogiro from the air if satisfactory dispersion and wetting of the spray material is attained. The cost of spraying wooded areas by autogiro is shown to be considerably cheaper than ground spraying.

60. Field Notes on the Life History of *Hylurgopinus rufipes* (Eich.) (10 min., lantern.) CHARLES H. MARTIN, Ithaca, N. Y.

Ninety per cent of the *H. rufipes* adults entering elm logs from May to September had entered by June 7. These were adults from hibernation. The other 10 per cent appearing in the summer had overwintered as larvae. Most larvae hatching before July 1 become hibernating adults the same season; a few hibernate because of a diapause condition, while early season larvae become adults which lay eggs after July 1. Most all larvae hatching after July 1 hibernate as larvae.

61. Organized Control in a Forest Tentless Caterpillar, *Malacosoma disstria* Hbn, Outbreak. (10 min., lantern.) A. G. RUGGLES and T. L. AAMODT, St. Paul, Minn.

Certain biological aspects and methods of organization and control of the most extensive outbreak known to occur in the history of Minnesota.

62. On Certain Habits of Elm Bark Beetles. (10 min., lantern.) B. J. KASTON and D. S. RIGGS, New Haven, Conn.

Data are given on feeding and hibernating tunnels. Analogous to the well-known crotch and twig feeding of *Scolytus multistriatus* is the making of bark tunnels in healthy elms by *Hylurgopinus rufipes*. The relation of this habit to the possibility of the latter species spreading the Dutch elm disease is pointed out.

63. Observations on the 1937 Epidemic of the Walnut Caterpillar in Missouri. (5 min.) LEONARD HASEMAN, Columbia, Mo.

This year Missouri had two broods, the caterpillars of the second brood completely stripping the leaves from practically every black walnut, hickory and pecan tree in the state during August and September.

64. Some Effects of Varying Conditions on Infestation of Angoumois Grain Moth Eggs by *Trichogramma*. (5 min.) LUIS ADOLFO COSTAS, East Lansing, Mich.

With increase in the number of *Trichogramma* while the number of *Sitrotroga* eggs remained constant, the percentage of parasitization increased, but the increase was not parallel to the increase in number of *Trichogramma*. One hundred per cent infestation of *Sitrotroga* eggs was not reached when the number of *Trichogramma* was twice the number of eggs. Age of *Sitrotroga* eggs, light intensity and the presence of foreign particles upon the eggs are shown to influence infestation by *Trichogramma*.

65. Some Parasites of Truck Crop Insects. (12 min.) B. J. LANDIS, Columbus, Ohio.

A list of natural enemies of truck crop insects reared at Columbus Ohio, between 1934 and 1936, inclusive, with notes on the abundance of some species.

66. Observations on Grasshopper Parasitism in 1937. (10 min.) J. D. DECOURSEY and WM. P. HAYES, Urbana, Ill.

Observations and counts throughout the summer were made to watch the development of parasitic flies, mites and nematodes throughout the summer, which showed them to be relatively unimportant in 1937.

67. *Sarcophaga aldrichi* Parker as a parasite of *Malacosoma disstria* Hbn. (15 min., lantern.) A. C. HODSON, St. Paul, Minn.

A discussion of the host-parasite relationships of these species with particular reference to the evidence for true parasitism. Detailed life histories are included. Competition between *Sarcophaga aldrichi* and other larval and pupal parasites is described.

68. Importance of Brief Reviews of the Literature on a Subject in Scientific Writing. (10 min.) ROGER C. SMITH, Manhattan, Kans.

A scientist seeks (1) to learn what is already known about a subject; (2) to extend the borders of science; and (3) to correlate the new with the old. There is a deplorable trend towards omitting the third step. Each observation is thus presented as if it were new and original. Journals requiring such omissions are contributing to lowering the usefulness of their papers.

69. A Proposed National Contest for Entomology Students. (15 min.) F. E. WHITEHEAD, A. & M. College, Okla.

A plan patterned somewhat after stock judging contests is proposed for entomology students. The benefits and disadvantages of such a contest are outlined as well as a proposed organization for conducting the contest.

70. We, the Teachers. (15 min.) JOHN T. CREIGHTON, Gainesville, Fla.

71. Aliphatic Thiocyanate Investigations. (10 min.) JOHN T. CREIGHTON, Gainesville, Fla.

Deals with control of scales of citrus and ornamentals, also with control of aphids and whiteflies.

72. Comparative Insecticidal Value of Thio and Iso-thiocyanates. (12 min.). NATHANIEL TISCHLER and ARNO VIEHOEVER, Philadelphia, Pa.

FINAL BUSINESS SESSION

1:30 p.m., Travertine Room

Papers Carried Over.
Report of Committee on Resolutions.
Report of Committee on Membership.
Report of Advisory Committee of Journal.
Nomination of Journal Officers by Advisory Committee.
Report of Committee on Nominations.
Election of Officers.
Miscellaneous Business.
Fixing Time and Place of Next Annual Meeting.
Adjournment.

F. C. BISHOPP, *President*
Washington, D. C.

ERNEST N. CORY, *Secretary*
College Park, Md.

CODLING MOTH CONFERENCES

The Association Committee on Codling Moth has arranged for a general conference on the codling moth problem to be held at Spokane, Washington, January 26 and 27. The conference will start at 1:30 p.m., January 26, and will follow immediately after the Annual Western Cooperative Spray Project Conference, which is composed of a group of official workers in the northwestern states and in British Columbia, and which is to start Tuesday, January 25. Arrangements for the exact place of meeting will be announced later. The Committee on Codling Moth hopes that a number of eastern entomologists will find it possible to attend the Spokane conference.

A shorter round-up for a discussion of the codling moth problem is also to be held at Indianapolis on the afternoon of December 27.

B. A. Porter, Chairman, Codling Moth Committee

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COTTON STATES BRANCH

PAPER-READING SESSION, TWELFTH ANNUAL MEETING
San Antonio, Tex., February 1937

Temperatures at Which Boll Weevils Freeze

EPHRAIM HIXSON and C. A. SOOTER, *Oklahoma A. & M. College, Stillwater*

IN a number of the cotton belt states since the winter of 1902–03, adult boll weevils have been collected and placed in hibernation cages every year for the purpose of determining the percentage of survival. In some cases the minimum temperature in the cage material was recorded, but no attempt was made to determine the actual temperature at which the individual weevils would freeze. Therefore, the low temperature fatal to the cotton boll weevil has long been a moot question.

Hunter & Pierce (1912) concluded "that areas having a minimum winter temperature of 10° F would experience but little injury to cotton from the attack of the boll weevil." Pierce (1916) concluded "that temperatures below 10° F were absolutely fatal to all stages of the boll weevil." Observations in Oklahoma over a period of seven years and especially following the severe cold of January 1930 did not bear out the earlier conclusions as to the resistance of the weevils to cold, or else they had very good shelter. The entire state had temperatures below zero Fahrenheit, and at Eufaula, Okla., where the first adult boll weevils were found on seedling cotton in June 1930, the minimum temperature was −19° F. Temperature records taken within shelter available to hibernating weevils under natural conditions showed that frequently during the winter the temperature dropped below 10° F and many times below 0° F yet the fields were always infested with adult weevils the following spring. The fall of temperature within the shelter was at a retarded rate compared to the air temperature and in most cases never reached the minimum of the air temperature. The gradual drop in temperature under shelter may be sufficient to permit hardening and may account for survival during severe cold, although the minimum may be reached only a few hours after this point has been reached outside. Within 48 hours between January 18 and 20, 1935, at Stillwater, Okla., the temperature dropped from 62° to −1° F in the cages. Sudden changes in temperature are not unusual in this area, but they are not always that

extreme. Robinson (1927) found that gradual exposure to cold decreased the free water present in the tissues of moth pupae, and likewise, lowered their undercooling temperature. He concluded that there was a direct correlation between the amount of bound water in the tissues and the undercooling temperature. He also found that the granary weevil did not bind water but actually lost bound water until death occurred. Payne (1926) found that native wood borers gradually became hardened to cold from fall to winter and in the spring froze at much higher temperatures. Hixson & Sooter (1936) found that chinch bugs froze at lower temperatures in February than in March.

The weevils used in this study were from stock collected in the local cotton fields during October and November, prior to the first killing frost, and were fed with cotton squares and succulent stems until used or placed in hibernation. Injured weevils were discarded, otherwise no attempt was made at selection. The weevils in the November series were

Table 1.—Undercooling and freezing temperatures and degrees of rebound of the cotton boll weevil, Stillwater, Okla., 1935.

Month	No. Weevils	Undercooling Temperatures			Freezing Temperatures			No. Degrees Rebound		
		Max.	Min.	Mean	Max.	Min.	Mean	Max.	Min.	Mean
Nov.	422	26.6	−9.4	6.6	30.2	−5.8	10.8	12.2	1.1	4.1
Dec.	344	23.	−4.	13.5	26.6	1.4	15.8	6.7	1.1	2.3
Jan.	64	17.6	−2.2	9.5	23.	5.	14.8	9.	1.1	5.1
Feb.	120	17.6	−7.6	6.1	19.4	−2.2	10.2	9.	1.1	4.2
Mar.	51	19.4	−2.2	10.9	21.2	3.2	14.6	6.7	1.1	3.7
Summary	991	26.6	−9.4	9.32	30.2	−5.8	12.7	12.2	1.1	3.6

taken direct from the feeding cages and frozen without any precooling, forced hibernation, or other artificial handling, except that necessary to collecting and freezing. Those weevils frozen in December were from the same stock as those frozen in November, except that they spent a month in forced hibernation. Those frozen in January, February and March were collected in October and November of 1934 and placed in hibernation cages, filled with native grass hay, where they remained until needed for freezing. The equipment used and the procedure in taking these data was the same as reported in an earlier paper by the authors (Hixson & Sooter, 1936).

Table 1 shows the number of weevils used and the maximum, minimum and mean undercooling and freezing temperatures, and the rebound in degrees Fahrenheit for each month. It is quite noticeable that the mean temperatures of the November and February series are almost identical and that the December and March series are also similar. The extremely low undercooling temperatures for November cannot be accounted for since the weevils had no chance to harden as did the other series. The lowering of the undercooling point did not have a tendency to shorten the rebound as one would expect, on the basis of Robinson's (1927) results with moth pupae, when the specimens were as nearly as possible under natural conditions. When the specimens were precooled there seemed to be a tendency for a lowering undercooling temperature and a shortening of the rebound. Fifty-two weevils were withdrawn from the December series and placed in an electric refrigerator where they were held at 37° F for five hours. They were then frozen as the others of

the series. The mean undercooling temperature for this precooled group was 12° F compared to 13.7° F for the 282 which were not precooled. The rebound was shortened from 2.42° to 1.85° F for those precooled. The weevils frozen in November were exposed to a mean temperature of 63° F in the field for the month prior to freezing. The other series frozen in December, January, February or March were exposed to mean temperatures during these months of 54.2, 48.5, 45.6 and 45° F respectively in the cage the month prior to freezing. This does not indicate that precooling lowers the undercooling temperature since the March series was exposed to a steadily declining mean temperature from January and ex-

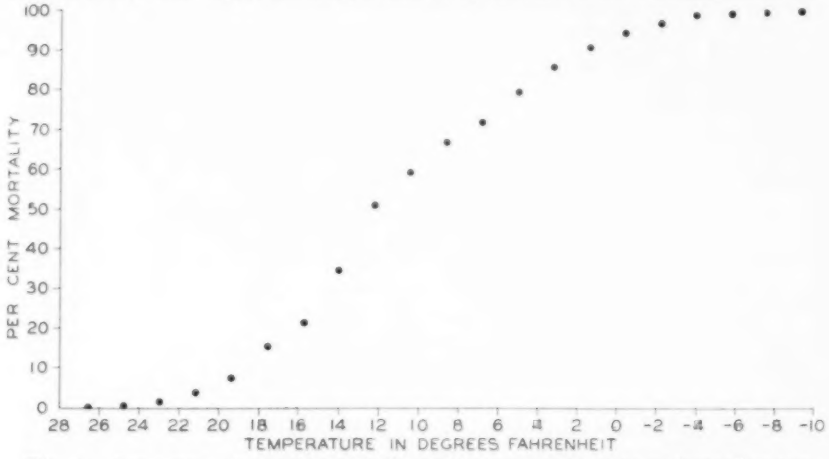

Fig. 1.—Summary of mortality of boll weevils from exposure to undercooling temperatures.

posed to the lowest monthly mean temperature of any series prior to freezing, yet the mean undercooling temperature of this group was 10.94°, the second highest of any series.

The percentage of mortality of the boll weevil at different low temperatures is shown in fig. 1. This curve shows the extreme range of undercooling during the winter months. It also shows that 6 per cent of the weevils can survive a temperature of 0° F, a percentage much higher than normally survived in cage experiments and a much greater percentage than apparently survive under natural conditions. On an average, about 3 per cent is the maximum cage survival, according to Sanborn (1934) although during the winter of 1930–31, 30 per cent survived in a cage at Idabel where the minimum air temperature was 18° F. Cold in this instance should have accounted for only 15 per cent mortality.

It is evident from the above data that low winter temperatures should reduce the hibernating weevil population to a minimum. With this in mind the data in table 2 are presented to show the relationship between the minimum winter temperatures at Idabel and Henryetta, Okla., and the number of hibernated weevils per acre in cotton fields the following spring near these places. Idabel is in the southeastern corner of the state where the highest winter temperatures and the greatest annual rainfall

occur. Henryetta is in the northern limits of constant infestation from hibernated weevils.

The relation of minimum winter temperature to maximum weevil population the following spring at Idabel and Henryetta, Okla., is shown in table 2. The maximum number of weevils per acre was the record for one field only, the average was for all fields examined in each area and in the same fields when possible. The minimum temperature was taken from the United States Weather Bureau records for each locality, and it occurred during either January, February or March, but never in December. Following winters of low minimum temperatures, the field population was small, as shown in table 2. The growing seasons prior to the small spring populations of 1933 and 1935 were rather a contrast to each

Table 2.—Relation of minimum winter temperature to maximum weevil population the following spring at Idabel and Henryetta, Okla.

Winter	Henryetta			Idabel		
	Min. Temp. °F	Max. No. Weevils per Acre	Av. No. Weevils per Acre	Min. Temp. °F	Max. No. Weevils per Acre	Av. No. Weevils per Acre
1930–31	11	160	125	18	500	310
1931–32	10	320	150	15	1030	530
1932–33	−5	40	30	0	280	105
1933–34	12	860	410	16	990	622
1934–35	2	80	80	8	330	183

other. The rainfall in 1932 was above normal, which resulted in a large weevil population, up to frost (an outbreak year), while 1934 was extremely dry and the fields had a continuously small weevil population until fall, when a large population was produced due to heavy rains and a late growing season, Fenton & Hixson (1935).

Summary.—The cotton boll weevil is much more resistant to cold than was formerly supposed. The undercooling temperatures of 991 boll weevils show a range from 26.6° to −9.4° Fahrenheit. Those undercooled in November and February were the most resistant, those undercooled in December and March were the least resistant. Winters having low minimum temperatures were followed by small field populations of hibernated weevils whether the population the previous year was large or small.—10-14-37.

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Possibilities of Reducing Overwintering Pink Bollworm Population in the Soil

As Shown by Stripping Tests

A. J. Chapman and H. S. Cavitt, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

The majority of the overwintering larvae of the pink bollworm, *Pectinophora gossypiella* Saunders, hibernate in the seed or lint in the trash on the surface of the soil, and in the soil. Although a relatively small part of the overwintering population is found in the soil it is an extremely important part in causing an infestation the following year because these larvae cannot be destroyed by a field clean-up. Tests were conducted at Presidio, Tex., during 1935 and 1936 in an effort to determine to what extent the soil population could be reduced by stripping the plants of all fruiting forms at different dates in October and early in November.

A small tract of uniform cotton 12 rows in width and approximately

Table 1.—Relation between time when all fruiting forms were removed from cotton plants and number of pink bollworm larvae found in the soil, 1935 and 1936.

Date Stripped	1935		1936		Two-Year Average	
	Av. No. Larvae per Sq. Yd.	Estimated No. Larvae per Acre	Av. No. Larvae per Sq. Yd.	Estimated No. Larvae per Acre	Av. No. Larvae per Sq. Yd.	Estimated No. Larvae per Acre
October 1	6.4	30,976	2.2	10,648	4.3	20,812
October 15	12.4	60,016	3.6	17,424	8.0	38,720
November 1	20.6	99,704	6.7	32,428	13.65	66,066
November 15	26.4	127,776	6.9	33,396	16.65	80,586

100 feet long was selected in a field heavily infested with pink bollworms. This tract was divided into four plots of three rows each. The plants in one of these plots were stripped of all fruiting forms, that is, squares, blooms, and bolls, on October 1. This date was selected for the first stripping since it was thought that a majority of the larvae would enter the soil after this time. Furthermore, it is about the earliest date that the crop could be matured and the field clean-up started in this area. Similar strippings were made in the remaining plots on October 15 and on November 1 and 15. The strippings were discontinued after November 15, since as a rule the weather at Presidio is too cool for much worm activity after this date.

On December 14–18, approximately one month after the last stripping, soil samples were collected from the middle row of each of the plots stripped. In collecting the samples all of the plant and surface trash was first removed. A square-yard sample of soil approximately 4 inches deep was then dug and placed in sacks. Five samples were collected at representative points along the rows in the 1935 tests and 10 samples in the 1936 tests. The soil in the samples was washed out and the pink bollworm larvae remaining in the residue were recovered and counted. Results of the two years' tests were as shown in table 1.

Although there was a much lower soil population in 1936 than in 1935 the trend of the results for both years was the same; that is, the earlier in the fall the plants were stripped the lower the soil population. The relatively small increase in the population between the November 1 and November 15, 1936, strippings was attributed to an early frost. In 1936 frost occurred on November 4, while in 1935 it did not occur until November 12.

When the population from similar dates of stripping for the two years' tests are averaged and calculated on a percentage basis they show that stripping on October 1 reduced the soil population approximately 75 per cent, on October 15, 51 per cent, and on November 1, 18 per cent.

The results of these stripping tests indicate that early maturity of the crop combined with early picking and clean-up of the fields would greatly reduce the overwintering population.—3-20-37.

Parasites of Pink Bollworm in Northern Mexico

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During the last few years considerable attention has been given to the biological control of the pink bollworm of cotton, *Pectinophora gossypiella* Saunders, in the Big Bend district of Texas and the Laguna district of Mexico. The Laguna is an irrigated district in the states of Durango and Coahuila in northern Mexico where large acreages of cotton are grown. The pink bollworm was introduced there in 1911, and this is the oldest and largest heavily infested area on the North American continent.

Limited observations have been made on the native parasites of the Laguna district by agents of the U. S. Department of Agriculture since 1917. More intensive studies have been made since 1933, when the introduction and colonization of introduced species were undertaken, to determine the changes in abundance and adaptation of the native parasites to the pink bollworm during the 25 years this insect has been present. Loftin, McKinney & Hanson (1921) found three species of larval parasites of the pink bollworm in the Laguna in 1918 and 1919, a few years after the pink bollworm population had become heavy, but their scarcity is indicated by the fact that only one specimen of each species was taken. Three years later, in 1921 and 1922, Ohlendorf (1926) found parasites more numerous, *Microbracon mellitor* (Say) and *Habrobracon gelechiae* Ashm.[1] [= *Microbracon gelechiae* (Ashm.)] being the most abundant species, although several other unidentified species were reared. The maximum parasitization observed was 33 per cent in blooms, although the general average was much lower.

In the more recent studies, one species of Diptera and at least four

[1] According to C. F. W. Muesebeck, "this in all probability represents a misidentification. It is very likely that the species involved was *Microbracon platynotae* (Cush.), which is very similar to *gelechiae*."

species of Hymenoptera native to the Laguna have been found parasitic on the larvae of the pink bollworm. Five other native species occur that may also attack the pink bollworm. Several fields have been observed in which approximately 75 per cent of the pink bollworms in blooms were killed by native parasites. These parasites are undoubtedly increasing in importance, but they do not exercise sufficient control to prevent heavy annual infestations and damage.

***Anachaetopsis* sp.**—On numerous occasions a small tachinid fly was reared from field-collected pink bollworms found in cotton blooms. These were identified by D. G. Hall as *Anachaetopsis*, probably a new species. Attempts made to rear the species in the laboratory were unsuccessful. The species was rather abundant in the fields, but no data were gathered to indicate its value as a control for the pink bollworm.

***Microbracon platynotae* (Cush.).**—This is a small, almost entirely black braconid, generally distributed over the Laguna, and is probably the most abundant of the parasites here discussed. *M. platynotae* attacks the pink bollworm larvae in squares, blooms and bolls. The female is able to pierce the square with the ovipositor and sting the larva while it is feeding within the square. When the pink bollworm is in a blossom the female usually enters and attacks the naked larva.

It would appear that the species would be unable to attack pink bollworms in bolls on account of the shortness of its ovipositor, but such is not the case. The pink bollworm larva frequently cuts an exit hole some time before it is ready to leave the boll. The hole may be left closed by a thin layer of tissue that is only partly cut away or it may be left entirely open. It is the custom of the female of *M. platynotae* to enter these exit holes and, when she encounters a pink bollworm in the tunnel, to sting the larva and deposit eggs. In this way a considerable percentage of the pink bollworms in green bolls may be parasitized. In open bolls the female crawls down among the fibers of the locks in search of pink bollworms that may be webbed up in the lint. When the parasite can get to the cocoons of the long-cycle pink bollworm larvae, it pierces the cocoon wall, stings the larva, and deposits eggs. The parasite larvae develop within the cocoon and when they reach the adult stage cut their way through the cocoon wall.

The species is easily reared in the laboratory. The most satisfactory rearing technic is the embroidery hoop method developed by Noble and Hunt at the Presidio, Tex., laboratory. In this system of rearing approximately 50 pairs of the parasites are put in a cloth-covered cage. To subject the worms to the parasite attack a piece of heavy wrapping paper is placed over the inner ring of an embroidery hoop, and pink bollworms are placed on the paper and then covered with a piece of muslin. The outer ring is then placed over the whole, clamping the cloth and paper together with the larvae between. The embroidery hoop is then placed against the cloth cover of the cage in such a way that the two cloth surfaces come together. The female parasites then deposit their eggs through the cloth on the worms in the embroidery hoop. After an exposure of 24 hours the hoop is removed to a suitable place for the development of the parasite eggs and larvae. After three or four days the hoops and cloth may be removed. The developing parasite larvae and the pink boll-

worms will adhere to the paper, where the parasite larvae continue to develop and finally spin cocoons.

In 1935 several thousand of the parasites were reared in the Torreon parasite laboratory and released in a small cotton field near the city. At the time of the release there was an infestation of pink bollworms of about 90 per cent in cotton blooms. Collections of squares and blooms taken a few days before the release showed no specimens of *Microbracon platynotae* present. Three weeks after the release the pink bollworm infestation was reduced to about 50 per cent, and a collection of blooms showed a large population of *M. platynotae*. This indicates that this parasite is capable of controlling the pink bollworm to some extent.

On numerous occasions specimens of *Microbracon platynotae* were recovered from collections of flower heads of blueweed, *Helianthus ciliaris*. Examination of the flower heads showed a large number of small lepidopterous larvae, adults of which were determined by August Busck as *Isophrictis*, new species. Larvae of *Isophrictis* sp. exposed to *M. platynotae* became parasitized. This alternate host is of considerable interest, since the blueweed is one of the most common and widely distributed weeds in the Laguna district, and the flower heads are heavily infested with *Isophrictis* sp. This insures a more or less constant reservoir of *M. platynotae* in or near the cotton fields.

***Microbracon mellitor* (Say).**—This insect is well known as a boll weevil parasite in the United States. It occurs generally over northern Mexico where cotton is grown and is parasitic on both the boll weevil and the pink bollworm. Under laboratory conditions no preference was shown by *M. mellitor* between the larvae of the boll weevil and those of the pink bollworm. In the cotton field it was found that this species parasitized the pink bollworm in squares, blooms and bolls. The female of *M. mellitor* has a fairly long ovipositor and is able to pierce the square or wall of a green cotton boll and parasitize larvae that are near the surface. In a laboratory test 10 green bolls were placed in a cage containing a number of females of *M. mellitor*. After a two-day exposure the bolls were examined and found to contain 82 pink bollworms, 60 of which had been parasitized. *M. mellitor* may be reared with moderate success by using the same technic as described for rearing *M. platynotae*.

***Perisierola cellularis* var. *punctaticeps* Kief.**—This parasite was originally described from California and has been rather commonly reared from the pecan-infesting Lepidoptera *Acrobasis caryae* Grote and *Laspeyresia caryana* Fitch. It has also been taken in Louisiana and is quite generally distributed over the cotton-growing region in northern Mexico, where it is parasitic on the pink bollworm. The activity of this parasite is largely restricted to pink bollworms in the open blooms, although the species will attack the pink bollworm wherever it can gain access to the larvae. In the cotton field the parasite has been observed entering the exit holes in green cotton bolls, and crawling among the fibers in open bolls in search of pink bollworm larvae.

In the laboratory the paralyzing of pink bollworm larvae has been observed repeatedly. The female parasite jumps upon the back of the pink bollworm and strokes it with her antennae, gradually moving forward. She then grasps the dorsal surface of the larva just back of the

head with her mandibles and curls her abdomen around the head until she is able to sting the larva just posterior to the labium. When stung, the larva struggles for a short time and then becomes quiescent. The shortest time observed in which the female paralyzed a larva was two seconds and the longest five seconds. After the larva is paralyzed, the female begins to chew on the ventral surface of the larva and later drags it about for some time before depositing her eggs. The eggs are cemented tightly to the larva and cannot be removed easily even with the aid of brush and needle. When the eggs hatch, the parasite larvae attach themselves firmly to the host larva. It is practically impossible to transfer the larvae from one host to another.

Perisierola cellularis var. *punctaticeps* is easily propagated in the laboratory by placing a male and female in a small vial on an inclined rack with an exposed pink bollworm larva. The pink bollworm is removed after 24 hours and a fresh larva is placed in the vial. The parasitized larvae are kept in culture dishes on sheets of filter paper where no further attention is needed until the adults emerge. Under laboratory conditions the females deposit an average of six eggs per day, and as many as 15 parasites may develop on a single pink bollworm. With a temperature of approximately 80° F the eggs hatch in about 20 hours, and the larval and pupal stages require 10 to 13 days.

Pink bollworms that had undoubtedly been paralyzed by this species were frequently observed in cotton fields, but only occasionally were eggs found on the larvae. After considerable observation it was learned that in the field the female of *Perisierola cellularis* var. *punctaticeps*, after paralyzing the pink bollworm, usually leaves the worm for a short time and then returns to it and removes it from the bloom or boll before ovipositing on it. The paralyzed worm is taken to a crack in the soil or to a suitable hiding place beneath a bit of bark or trash. A female has been observed to drag a paralyzed pink bollworm as much as 10 feet across a concrete floor to a suitable place of concealment.

This habit of removing the paralyzed larva from the plant makes it very difficult to estimate the efficiency of the parasite in the control of the pink bollworm. In one instance where there was a pink bollworm infestation of 60 to 70 per cent in blooms, it was estimated that 20 per cent of the larvae had been stung by *Perisierola cellularis* var. *punctaticeps*. While it has not been possible to obtain any definite data as to its efficiency, it is believed that this parasite may play an important part in the control of the pink bollworm.

***Catolaccus hunteri* Crawford.**—This is a rather common parasite of the boll weevil which was taken repeatedly from collections of cotton blooms and squares. In many of these collections there were many pink bollworms but scarcely any boll weevils. From the relatively large number of *C. hunteri* taken in these collections it seems probable that it is also a a parasite of the pink bollworm. No attempt has been made to rear the species in the laboratory.

Other possible parasites.—Four other species of parasites also emerged from the collections of squares and blooms similar to those mentioned above. The insects taken from these collections were identified as *Zatropis incertus* (Ashm.), *Goniozus* sp., *Angitia* sp. and *Chelonus albobasilaris*

Ashm. It is quite probable that these insects are parasitic on the pink bollworm although they have not been definitely reared from it. Another species, *Chelonus texanus* Cress., that may possibly be parasitic on the pink bollworm was collected by sweeping in a cotton field, but information as to its host was not obtained.

Introduced parasites.—Four parasites that do not occur naturally in this region have been introduced through the cooperation of the Division of Foreign Parasite Introduction and the Presidio, Tex., laboratory of the Bureau of Entomology and Plant Quarantine. These insects are *Exeristes roborator* (F.), *Microbracon brevicornis* (Wesm.), *Microbracon kirkpatricki* Wilk. and *Chelonus blackburni* Cam.

Approximately 25,000 specimens of *Exeristes roborator* have been reared and released in the Laguna district over a period of three years, but the species has apparently not become established.

Microbracon brevicornis was the first parasite introduced. Several thousand specimens were liberated and a few were recovered about one month after the release was made, but later collections failed to include the species.

About 60,000 specimens of *Microbracon kirkpatricki* have been reared and released in the cotton fields of the Laguna, but only a very few specimens were recovered after the releases.

Approximately 20,000 specimens of *Chelonus blackburni* were reared and released. This insect gave very favorable indications of becoming established. Specimens were recovered as far as 500 meters from the point of release. The species is apparently well adapted to summer conditions in the Laguna district, but it remains to be learned whether it will be able to survive the winter.

Of the four species introduced into the Laguna district, *Chelonus blackburni* has shown the greatest indications of becoming of value in combating the pink bollworm.—3-15-37.

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Imported Parasites of Pink Bollworm at Presidio, Tex., 1932–36

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During the last five years, six species of foreign parasites of the pink bollworm *Pectinophora gossypiella* Saund., were imported through the cooperation of the Division of Foreign Parasite Introduction of the Bureau of Entomology and Plant Quarantine and propagated in the laboratory at Presidio, Tex., in an attempt to establish them in the United

States, Mexico and Puerto Rico. Table 1 lists the species and their place of origin, and shows the localities and number of each species released in areas infested with the pink bollworm.

With the exception of *Elasmus platyedrae*, all of the species have been liberated during at least one season and all were recovered during the same summer that they were released, but collections in following years have as yet given no evidence that any have become established.

The laboratory breeding is done under controlled temperature and humidity, held practically constant at 80° F and 65 per cent relative humidity. All the species except *Chelonus blackburni* are ectoparasites and attack the late instars of the host larva. The breeding season for large-scale production of these species is short because pink bollworms cannot be collected in large numbers until late in the cotton-growing

Table 1.—Total pink bollworm parasites liberated, 1932–36.

Species	Place of Origin	No. Adults Liberated			
		Texas	Mexico	Puerto Rico	Total
Exeristes roborator F.	S. Europe	9,278	9,000	1,637	19,915
Exeristes roborator F.	Egypt	5,500		1,445	6,945
Microbracon brevicornis Wesm.	S. Europe	23,700	11,000		34,700
Microbracon kirkpatricki Wilk.	E. Central Africa	60,000	30,000	40,000	130,000
Microbracon mellitor Say	Hawaii	5,000			5,000
Chelonus blackburni Cam.	Hawaii	78,000		14,000	92,000
Elasmus platyedrae Ferrière*	Egypt				
Total		*181,478*	*50,000*	*57,082*	*288,560*

* The stock of *E. platyedrae* died in the laboratory before any releases were made.

season. No host larva other than the pink bollworm has proved satisfactory for large-scale breeding of these species, excepting *C. blackburni*, which can be bred in *Ephestia kuehniella* Zell.

Exeristes roborator.—Two strains of *Exeristes roborator* were colonized. Breeding of the European corn borer strain was discontinued after liberation each summer from 1933 to 1935, inclusive, with no evidence that it could maintain itself on the pink bollworm in the areas where tested. Slightly more than 80 per cent of the larvae of this strain survived the winter in hibernation cages at Presidio, but the adults emerged and died before the first generation of pink bollworms were available for their propagation. This species also breeds on the southwestern corn borer, *Diatraea grandisella* Dyar, but these larvae hibernate in the roots of corn and are not accessible during the winter. No alternate hosts have been found to carry the parasites until pink bollworms are available.

The Egyptian or pink bollworm strain of *Exeristes roborator* was liberated only in 1936, and very few data on the possibility of its becoming established have been obtained. The only difference in the two strains thus far observed was the difference in the sex ratio. The sexes of the pink bollworm strain were about equal in number, whereas the European corn borer strain produced a much greater number of males than females when reared on the pink bollworm.

***Microbracon brevicornis* Wesm.**—*Microbracon brevicornis* was liberated in 1932, 1933 and 1934. It oviposits only on larvae openly exposed or on those with which it can come into immediate contact. During the cotton fruiting season it can attack pink bollworms in blooms or immediately after they have cut their way out of bolls. The hibernating pink bollworms, however, are rarely accessible. This parasite does not have any definite resting period; and since the daily maximum temperatures at Presidio are usually high enough to permit activity it seems that for continuous breeding this species would require the presence of host larvae at all seasons. It did not survive the winter in hibernation tests conducted at Presidio and collections failed to show that it survived under field conditions. The breeding and liberation of this species have been discontinued.

***Microbracon kirkpatricki* Wilk.**—Liberations of *Microbracon kirkpatricki* were made during 1935 and 1936. This species has not been found to hibernate. Larvae placed in hibernation cages during November and the first part of December completed emergence early in January. The daily minimum temperatures during this period ranged from 15° to 60° F, and the daily maximum from 52° to 89° F. It seems that this species is better adapted to maintain itself in Texas than *M. brevicornis* because of its ability to parasitize hosts not exposed. Although it has not yet been found to overwinter, further breeding and liberation seem justified.

***Microbracon mellitor* Say (Hawaiian strain).**—The native strain of *Microbracon mellitor* occurring at Presidio attacks the pink bollworm but exerts negligible control. According to reports on this species it is of considerable importance as a parasite of the pink bollworm in Hawaii. It was thought that possibly the strain occurring in Hawaii might be different from that already present at Presidio and an attempt to establish it in the United States would be warranted. Breeding stock of the Hawaiian strain was imported in 1935 but liberations were not made until 1936. No data have as yet been secured on its establishment. It was found to overwinter in the larval stage with a survival of 61.58 per cent. Larvae also survived a seven-month period of cold storage at 38° to 40° F, with an emergence of 76.5 per cent.

***Chelonus blackburni* Cam.**—*Chelonus blackburni* oviposits in the egg of its host but completes its development in the larval stage. It breeds readily in the laboratory on *Ephestia kuehniella*. The principal liberations of this species were made in 1936. No data have been secured on its hibernation. It was found, however, that immature stages developing in *E. kuehniella* larvae placed in cold storage at 38° to 40° F for a period of three months completed development and emerged after removal. It is thought that this species will have the advantage of the other species in surviving the field clean-up by overwintering in pink bollworms in the soil.—3-15-37.

NARCISSUS bulb quarantines of Washington and Oregon were recently revised to include sanitation requirements on narcissus planting stock and to make certain changes in the required treatment for bulb flies and eelworm.

KANSAS and Missouri are brought within the list of states designated as infested with the oriental fruit moth under a revision of the Nevada quarantine relating to the pest, which was put into effect on October 1.

Tests for Boll Weevil Control
Using Latin Square Plat Arrangement, Tallulah, La., 1936

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A plat of approximately .7 acre of land, 126 feet by 242 feet, was required for this test. Sixteen plats were staked out and were arranged in a Latin square, with four replications for each treatment. Each treatment appeared once in each row and once in each column, and in no case in adjacent plats. Each plat was one-fortieth of an acre in area and consisted of six rows that were 3.5 feet in width and 51.86 feet in length. The rows were very carefully measured and were laid off with a hand-operated graden plow. On May 4 cotton seed of the variety D.P.L. 11 was hand-planted in hills 15 inches apart. The cotton was later thinned to two plants per hill. On June 2 nitrate of soda was applied to the cotton at the rate of 120 pounds per acre, and on July 7 a second application was

Table 1.—Records of square infestation by boll weevil on treated and untreated plats. Treatments were begun July 28.

DATE	AVERAGE PERCENTAGES, FOUR PLATS EACH, OF PUNCTURED SQUARES			
	Plats No. 1 Untreated	Plats No. 2 Calcium Arsenate	Plats No. 3 Calcium Arsenate–Lime 50:50	Plats No. 4 Calcium Arsenate–Sulfur 50:50
July 6	6.5	8.8	8.5	13.3
July 13	5.8	2.6	10.1	5.5
July 20	3.3	3.	5.9	3.6
July 27	12.9	14.6	17.5	14.4
August 3	36.5	21.	28.6	26.1
August 10	50.4	16.9	25.4	23.9

made at the same rate. Four plats numbered 1 were left untreated to serve as a check, four plats numbered 2 were dusted with calcium arsenate, four plats numbered 3 were dusted with a mixture of equal parts by weight of calcium arsenate and hydrated lime, and four plats numbered 4 were dusted with a mixture of equal parts by weight of calcium arsenate and a good grade of dusting sulphur.

As there was no initial infestation of the boll weevil, *Anthonomus grandis* Boh., in the plats, it was necessary to introduce boll weevils. On June 4 one pair, of overwintered boll weevils was introduced into each of the 16 plats and on June 10 another pair was introduced into each plat. On account of very unfavorable weather conditions for the multiplication of boll weevils during June, none of these boll weevils lived sufficiently long to deposit eggs in squares. On June 24 and 25 two pairs of first-generation boll weevils were introduced into each of the 16 plats. Conditions were favorable for the multiplication of boll weevils during most of July but were very unfavorable during August and September.

Table 1 presents square-infestation records made at weekly intervals from July 6 to August 10. These records, as well as the ones which follow, were all made on the two center rows in each plat. On July 6, 13 and 20

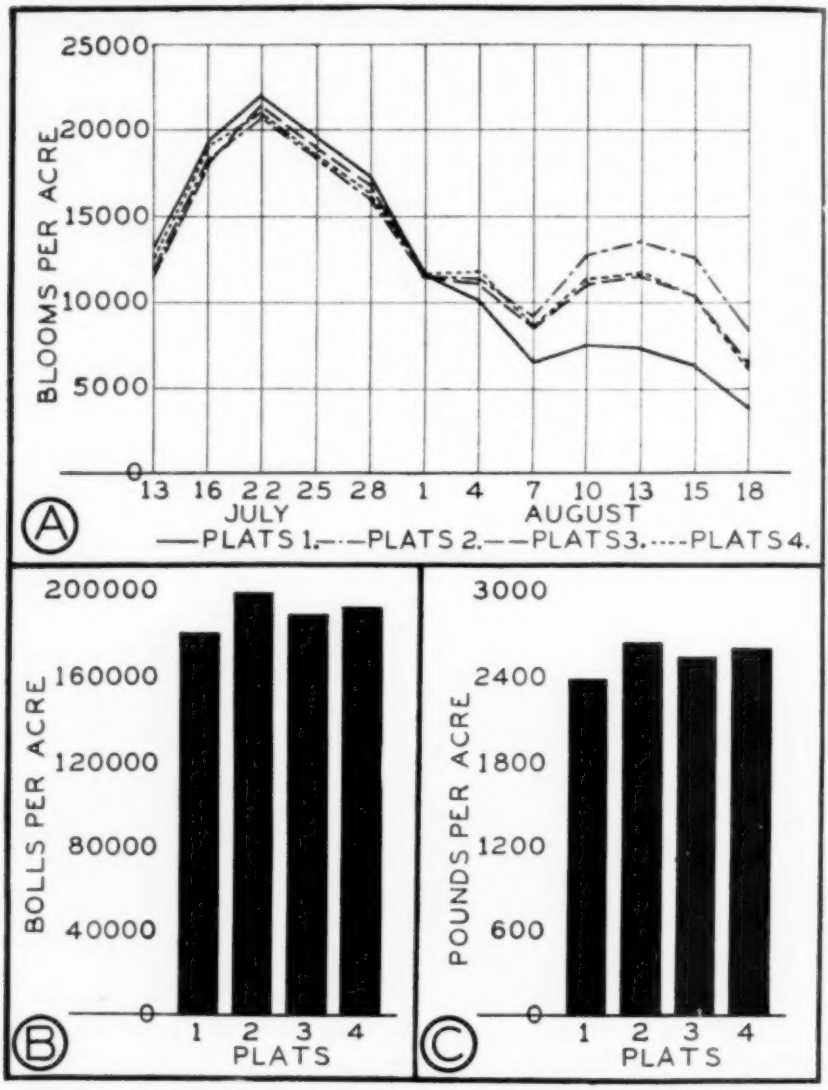

Fig. 1.—*A*, Average number of cotton blooms per acre from July 13 to August 18; *B*, average number of bolls per acre on August 26; *C*, average number of pounds of seed cotton per acre. Plats 1 untreated, plats 2 treated with calcium arsenate, plats 3 treated with calcium arsenate and lime 50:50, plats 4 treated with calcium arsenate and sulfur 50:50.

a comparatively light infestation was found in all of the plats. On July 27 the average infestation in plats 1 was 12.9 per cent; in plats 2, 14.6 per cent; in plats 3, 17.5 per cent; and in plats 4, 14.4 per cent. Applications of poison were started on July 28 and were continued at approximately

four-day intervals until August 26. A total of eight applications was made on each of the treated plats. Plats 2 received an average of 7.21 pounds of calcium arsenate per acre per application; plats 3 an average of 7.25 pounds of calcium arsenate and lime 50:50; and plats 4 an average of 7.62 pounds of calcium arsenate and sulfur 50:50. All applications were made with hand guns. Before and after an application was made to a plat, the gun was weighed on platform scales that would weigh to one-fourth of an ounce. The poison used was then computed upon an acre basis. On August 10 the average infestation in plats 1 was 50.4 per cent; in plats 2, 16.9 per cent; in plats 3, 25.4 per cent; and in plats 4, 23.9 per cent.

Figure 1, *A*, presents graphically bloom count records from July 13 to August 18, inclusive. It will be noted that after poison applications were

Table 2.—Average production in pounds of seed cotton per acre on treated and untreated plats.

Plat No.	Treatment	Average Yield per Acre	Difference from Check*	Difference from Calcium Arsenate
1	Untreated	2380		
2	Calcium arsenate	2640	260	
3	Calcium arsenate and lime 50:50	2544	164	96
4	Calcium arsenate and sulfur 50:50	2602	222	38

* The least mean difference that can be considered significant is 152.44 pounds.

begun on July 28 the greatest blooming occurred in plats 2, which were treated with calcium arsenate, followed by plats 4, which were treated with calcium arsenate and sulfur 50:50, and plats 3, which were treated with calcium arsenate and lime 50:50. The difference in blooming was very slightly in favor of the sulfur mixture over the lime mixture. Blooming was considerably greater in all of the treated plats than in the untreated plats.

On August 3 the average height of the plants in plats 1 was 44.38 inches; in plats 2, 43.56 inches; in plats 3, 45.38 inches; and in plats 4, 44.2 inches. These records indicate very uniform plant growth throughout the various plats, the greatest difference between any of the average heights being only 1.82 inches.

On August 26, plants on the two center rows in each plat were counted and the number was computed upon an acre basis. In plats 1 the average number of plants per acre was 18,990; in plats 2, 18,990; in plats 3, 19,320; and in plats 4, 19,290. The number of plants per acre was very uniform throughout all of the plats, the greatest difference between any of the averages being only 330 plants per acre.

On August 26 boll-count records indicated that there were 181,080 bolls per acre in plats 1; 199,560 in plats 2; 189,300 in plats 3; and 193,920 in plats 4. These figures are presented graphically in fig. 1. The greatest number of bolls was found in plats 2, which were treated with calcium arsenate, followed in order by plats 4, which were treated with calcium arsenate and sulfur 50:50, and plats 3, which were treated with

calcium arsenate and lime 50:50. Plats 1, which were untreated, showed the smallest number of bolls.

Table 2 presents the average yields for the three plats receiving different treatments. As the cotton was planted in plats forming a Latin square, the data were analyzed by the method of analysis of the variance. The variance attributed to soil heterogeneity was eliminated. Then the least mean difference between any two plats that could be considered significant was computed. This difference was found to be 152.44 pounds per acre. Plats 2, which were treated with calcium arsenate, produced an average of 260 pounds of seed cotton, or 10.9 per cent, more than the untreated plats. Plats 4, which were treated with calcium arsenate and sulfur 50:50, produced an average of 222 pounds, or 9.3 per cent, more than the untreated plats. Plats 3, which were treated with calcium arsenate and lime 50:50, produced an average of 164 pounds, or 6.9 per cent, more than the untreated plats. All these differences can be judged significant. There were no significant differences in yield, however, between any two of the various treatments with calcium arsenate, although the average increase in yield of the calcium arsenate treatments over those with calcium arsenate and lime 50:50 was greater than the increase in yield of the calcium arsenate treatments over those with calcium arsenate and sulfur 50:50.

Summary.—Infestation records indicated that the best boll weevil control was secured with calcium arsenate followed in order by calcium arsenate and sulfur 50:50 and calcium arsenate and lime 50:50. Records of plant height indicated uniform plant growth throughout the various plats. Plant counts indicated a very uniform number of plants throughout the plats. Bloom counts and boll counts indicated that there was a greater amount of fruiting in the plats treated with calcium arsenate, followed in order by plats treated with calcium arsenate and sulfur 50:50 and plats treated with calcium arsenate and lime 50:50, with the untreated plats producing the smallest amount of fruit. These records all seem to fit in very nicely with the yields.

It appears that the increased yields caused by the three different treatments used when compared with yields in untreated plats are significant; that the increased yield for calcium arsenate treatments over treatments of calcium arsenate and lime 50:50 is not significant; and that the increased yield for calcium arsenate treatments over treatments with calcium arsenate and sulfur 50:50 is not significant—3-15-37.

Cotton Flea Hopper, an Ecological Problem

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The cotton flea hopper, *Psallus seriatus*, has come to be generally considered one of the major insect pests in Texas. As such it has received intensive study by both state and federal workers for a period of more

than 10 years. In spite of the investigations which have been conducted and which have resulted in the development of satisfactory control measures, there are still probably more unsolved problems connected with this insect than with any other major pest attacking cotton in the southwest.

Flea hopper injury as a rule is greater on the heavier than on the lighter types of soils, and has attracted more attention in the black land region than in east Texas. It is a common observation that injury is worse within a cotton field than on the margin of the field, or than in cotton rows closely adjacent to other crops when strip planting is practiced.

These observations are a few among the many that have puzzled investigators of the cotton flea hopper.

The explanation of these occurrences may be found in the fact that injury to the cotton crop by the cotton flea hopper is due more to the scarcity of other plants or weeds such as primrose, the horsemints, and croton or goatweeds, which the insect prefers, than to any choice it exercises in its selection of cotton.

That cotton is not a preferred host of the cotton flea hopper is a most important point. The weeds mentioned are always more heavily infested in the blooming stage than is cotton when growing in the same vicinity. However, cotton is acceptable to the insects when it is succulent, but whenever the growth of cotton is retarded because of dry weather or heavy fruiting, most of the adult flea hoppers take flight for longer or shorter distances and may be carried out of the fields by the winds. The insects continue this migrating until suitable host plants are found.

Let us look at the situation when the insects hatch from the overwintered eggs that were laid in the fall weeds. These weeds often are in locations where the favored spring host plants of the flea hopper are few and far between. After hatching, some of the young nymphs may be whipped away by the winds, but practically all of the newly hatched insects during March and April are forced to feed on most any form of tender vegetation. For example, they can exist and mature upon grass.

With maturity comes a greatly increased power of selection, and the young adult flea hoppers are not slow to take advantage of their ability to fly and search for host plants that are suitable, especially when the spring vegetation has been retarded by weather conditions. Once the insects start flying, there is no telling where they may come to rest.

Generally, the first adults are found soon after cotton comes up. As the young cotton becomes large enough to afford some shelter, and succulent enough to be both satisfactory for food and egg-laying purposes, it is not surprising that the flea hopper temporarily accepts this new plant as a welcome change from its enforced diet while in the nymphal stage.

If the cotton field is typical of those in the black land area, it may be difficult for the insect to find anything except cotton on which to feed and lay eggs. The fields are usually large, more land is in cultivation, and spring hosts other than cotton are comparatively scarce. On the other hand, if the flea hopper drifts into a region where the soils are lighter or sandy in nature, the cotton fields are usually smaller, there is more uncultivated land and also a larger variety of weed hosts on which the insect may feed.

When studying the flea hopper infestation in the sandy land areas it has been observed that there often would be one or more spots within a field where the infestation would be heavier and that these points of heavier infestation frequently change from week to week. Some of the highest counts were recorded in fields which had no weed hosts near.

Is it not reasonable to suppose, then, that as the flea hoppers attempt to find other hosts, more of those insects that are in the small cotton fields or in the edges of the large cotton fields may be more successful in getting away to another environment? And, furthermore, the presence of a tall-growing crop, such as grain sorghum or corn planted adjacent to or in strips through a cotton field according to the practice in the black land area, may cause these migrating flea hoppers to rise higher while in flight and possibly be carried further by the winds. Whether or not this explanation is correct, the practice of strip planting with tall-growing crops is well established and has been found to be beneficial in materially reducing a medium to light infestation of flea hoppers in the adjacent cotton rows.

In general, the smaller the cotton fields the sooner will flea hoppers leave them and seek their preferred weed hosts. The larger the cotton-planted area and the cleaner the cultivation, the more severe the flea hopper infestation and the greater the proportionate damage will be, other things being equal. Of course, the water-retaining capacity of the heavy soils is a factor in the length of the period that cotton may remain succulent and still attractive to the flea hopper.

Since it has been shown that there is a relation between the extent of flea hopper injury and the immediate environment of the cotton fields, the remedy would consist in changing the environment in such a way as to enable the cotton grower to avoid much of the damage occurring in cotton in an area where the flea hopper has difficulty in finding its preferred food plants.

The changes suggested are for the black land area; they are not new but simply good farming and soil conserving practices. Strip planting, a form of crop rotation and diversification, is recommended. These suggestions are not recommended as a substitute for dust applications under conditions of heavy infestation, but if practiced may prove valuable in preventing considerable insect injury when the infestation is medium.

Give the cotton flea hopper a chance to find its preferred hosts and thereby relieve to some extent the necessity for its having to feed on cotton.—3-4-37.

Cotton Flea Hopper Control in 1936

K. P. Ewing and R. L. McGarr, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

In 1935 mixtures of Paris green and sulfur showed up to good advantage in controlling the cotton flea hopper, *Psallus seriatus* Reut. Late-season experiments with a mixture of calcium arsenate and sulfur showed

this material also to be promising. In 1936 eight experiments were conducted at Port Lavaca, Tex., to compare sulfur, a mixture of 10 per cent Paris green and 90 per cent sulfur, and a mixture of 20 per cent calcium arsenate and 80 per cent sulfur for the control of this insect. The sulfur was 97–98 per cent pure, with 98–100 per cent passing a 325-mesh screen. The Paris green and the calcium arsenate were of standard commercial quality. The mixtures were prepared by a commercial company in a large mixing machine to insure thorough mixing.

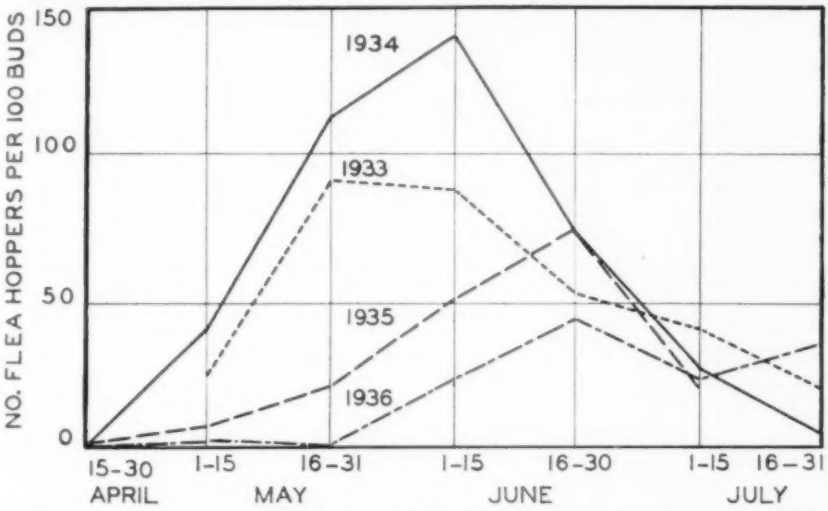

Fig. 1.—Average cotton flea hopper infestation in miscellaneous untreated fields of cotton in Calhoun county, Tex., 1933–36.

Excessive rains lowered the yield of cotton and materially reduced the gain that would otherwise have resulted from the dusting. During May, June and July, the critical months of cotton fruiting in the Gulf coast section of Texas, the total rainfall at Port Lavaca was 25.96 inches. The rainfall in May was 10.4 inches, during the last four days of June it was 4.63 inches, and in July it was 10.93 inches. On July 15 the rainfall in Calhoun county ranged from 4.95 inches at Port Lavaca to 14 inches in the southern part of the county.

The infestation of cotton flea hoppers was much lighter and occurred later in 1936 than in any of the three preceding years. Figure 1 shows the average infestation in Calhoun county during May, June and July from 1933 to 1936, inclusive. These records are averages of weekly counts in an average of 20 fields, each record representing approximately 12,000 cotton plants.

Small-plot experiments.—There were four small-plot experiments, each comprising four 1-acre plots. Three plots were dusted, one with each material, and one was left untreated as a check.

DUST APPLICATIONS.—In two of the experiments the dusted plots received five applications, in one experiment they were dusted four times, and in one they were dusted twice, which made an average of four dust

applications per experiment. The dusting was done at five-day intervals in three of the experiments and at 10-day intervals in the other. The average quantities of dust per acre-application were as follows: Sulfur 12.33 pounds, Paris green and sulfur mixture 12.73 pounds, and calcium arsenate and sulfur mixture 12.86 pounds.

INFESTATION RECORDS.—Four to six infestation records were made in each experiment, the average being 5.3. For each record 300 terminal buds of cotton plants were inspected per plot. The first records were made between June 2 and 16 and the last records between July 20 and 25. In each experiment the first dust application was made the day after the first infestation record.

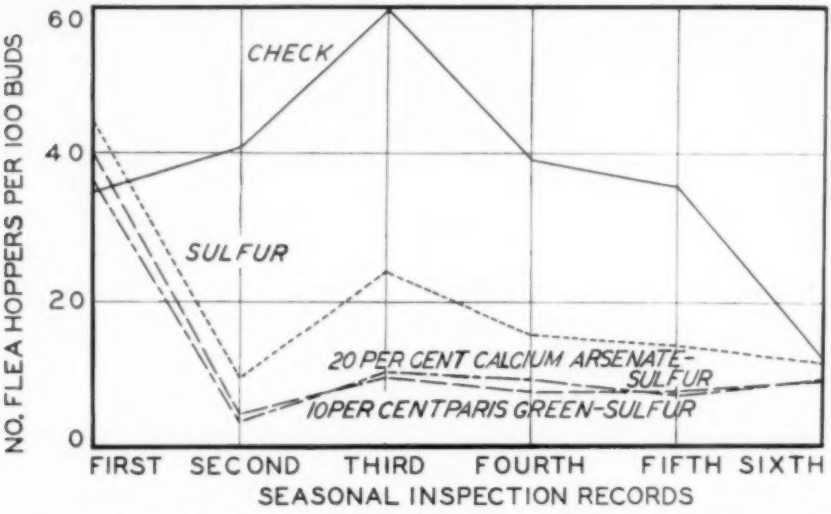

Fig. 2.—Cotton flea hopper infestation records in small-plot experiments at Port Lavaca, Tex., 1936, showing control secured from different treatments.

Figure 2 summarizes the cotton flea hopper infestation in the plots receiving the different treatments. It will be noted that there was very little difference in the control secured from the two mixtures, but that both mixtures gave better control than the sulfur. The average numbers of cotton flea hoppers per 100 buds, after dusting was begun, in the plots receiving the different treatments were as follows: check 39.5, sulfur 16.2, calcium arsenate and sulfur mixture 8.7, and Paris green and sulfur mixture 8.2.

BLOOM COUNTS.—The white blooms on the 10 middle rows of each plot were also counted. Three such records were made in three of the experiments and one in the fourth. These records, which are summarized in fig. 3, show practically no difference between the fruiting of the cotton in the plots dusted with the mixtures, the average being 3078 blooms per acre in the plots dusted with the Paris green and sulfur mixture and 3030 in the plots dusted with the calcium arsenate and sulfur mixture. The plots treated with sulfur averaged 2642 blooms, which is approximately

86 per cent as many as the plots treated with the mixtures, while the check plots averaged only 1186, or less than half as many as any of the dusted plots.

YIELD RECORDS.—The average yield from the check plots was 455 pounds of seed cotton per acre. The average gain from the Paris green and sulfur mixture was 127.3 pounds, from the calcium arsenate and sulfur mixture 94 pounds, and from the sulfur 88.3 pounds. The net profit per acre from the treatments was as follows: Paris green and sulfur mixture $1.79, sulfur $1.29, and calcium arsenate and sulfur mixture $1.12.

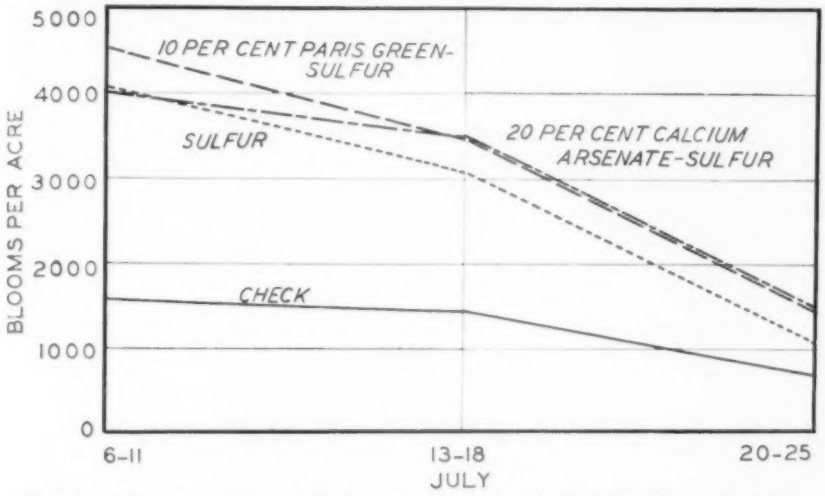

Fig. 3.—Bloom counts in small-plot experiments at Port Lavaca, Tex., 1936, showing fruiting of cotton in plots receiving different treatment for cotton flea hopper control.

Large-scale experiments.—Four large-scale experiments were conducted in a similar manner to the small-plot experiments except that team-drawn or tractor machines were used in distributing the dust and the average size of the dusted fields was 7.2 acres and of the checks 9.6 acres.

DUST APPLICATIONS.—In three experiments the fields were dusted twice, with about 10 days between applications, and in one experiment they were dusted once, making an average of 1.75 applications per experiment. In each experiment the first dust application was made one to three days after the first infestation record. The average quantities of dust applied per acre-application were as follows: sulfur 14.5 pounds, Paris green and sulfur mixture 13.2 pounds, and calcium arsenate and sulfur mixture 14.4 pounds.

INFESTATION RECORDS.—Four infestation records were made in each experiment. The first records were made between June 5 and 18, and the last records between July 22 and 24. A summary of these records is given in fig. 4. It will be noted that each dust gave considerable control of the cotton flea hopper, the two mixtures giving the best control and the

sulfur the poorest. After dusting was begun, the average numbers of cotton flea hoppers per 100 buds in the different plots were as follows: check 41.4, sulfur 19.1, Paris green and sulfur mixture 14, and calcium arsenate and sulfur mixture 13.7.

GAIN.—The average gain from the sulfur treatment was 133.8 pounds of seed cotton per acre, or a net profit of $4.52; from the Paris green and sulfur mixture 130.4 pounds, or a net profit of $3.94; and from the calcium arsenate and sulfur mixture 129.7 pounds, or a net profit of $4.18.

Summary.—Four small-plot experiments and four large-scale dusting experiments were conducted in 1936, comparing sulfur, a mixture of 10 per cent Paris green and 90 per cent sulfur, and a mixture of 20 per cent

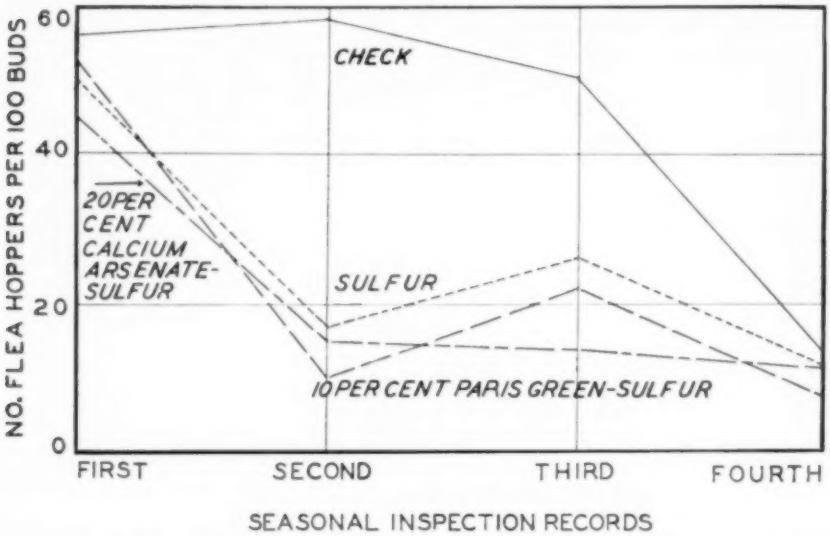

Fig. 4.—Cotton flea hopper infestation records in large-scale experiments at Port Lavaca, Tex., 1936, showing control secured from different treatments.

calcium arsenate and 80 per cent sulfur for control of the cotton flea hopper. Infestation records showed practically no difference between the control secured from the two mixtures, and both mixtures gave better control than the sulfur alone.

Bloom counts in the small-plot experiments showed that the cotton in the plots dusted with each mixture fruited about alike. In the plots dusted with sulfur there was an average of 86 per cent as many blooms as in the plots dusted with the mixtures, while in the untreated plots there were less than half as many as in any of the treated plots.

Excessive rains during the normal fruiting season seriously affected the yield and reduced the gain that might otherwise have resulted from the control measures. The average gain in pounds of seed cotton per acre from the eight experiments was as follows: Paris green and sulfur mixture 128.9 pounds, calcium arsenate and sulfur mixture 111.9 pounds, and sulfur 111.1 pounds.—3-1-37.

Thrips Damage to Cotton

E. W. Dunnam and J. C. Clark, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Severe injury by thrips was observed in experimental plots of cotton at Stoneville, Miss., during the spring of 1936, and the species *Frankliniella tritici* Fitch, *F. fusca* Hinds, *F. runneri* Morgan and *Sericothrips variabilis* Beach were identified as contributing to this damage. This infestation furnished an opportunity to study the possible variation in the percentage of thrips-damaged plants in 40 varieties when there was a difference in the number of stalks left in the hill and when the date of chopping was delayed, and to observe the effect that the damage to the plants might have on the time of fruiting, quantity of cotton produced and the quality of lint.

Methods.—In the plots available for this study there were 40 varieties, strains or selections, arranged systematically in eight replications. Each replication or series consisted of 40 rows 120 feet long. When the plants averaged about 12 inches in height each plant in all replications

Table 1.—Percentage of cotton plants damaged by thrips under different conditions of growth at Stoneville, Miss., in 1936. There were 40 varieties of cotton, with plants spaced approximately 12 inches apart in the drill.

Time of Chopping	No. Series Represented	Average No. Stalks per Hill	No. Plants	Per Cent Plants with Terminal Bud Destroyed
Early	6	2.79	80,267	9.24
Early	1	1.	4,882	21.02
Delayed one week	1	2.08	9,999	20.27
Summary	*8*	*2.62*	*95,148*	*11.*

was carefully examined and records were made of the injury caused by thrips. To secure uniform development in one series the plants in the drill were thinned to one stalk in the hill.

If the terminal bud on a plant throughout any of the eight series was entirely destroyed and side branches had developed, a conspicuous tag was placed on the plant, and a normal plant nearby that showed no trace of abnormality was selected as a control. As soon as blooms began to appear, small dated tags were attached daily to 25 blooms on each row throughout the season without respect to the type of plant. When the crop had matured, cotton samples were gathered by picking all cotton from damaged plants in each variety and from the selected normal plants growing by their side.

Results.—The results obtained from examination of the terminal buds of all varieties under the various conditions are presented in table 1.

In six series of early chopped cotton in which the hill consisted of an average of 2.79 stalks, the highest average percentage of plants with the terminal bud destroyed in any variety was 13.83, the lowest 5.51 and the average 9.24 per cent. In one series under corresponding conditions, but thinned to one stalk in the hill, the highest and lowest percentages

were 40.34 and 5, with an average of 21.02 per cent. In another series in which the hill consisted of an average of 2.08 stalks, and chopping was delayed one week, the highest and lowest percentages of damage were 38.56 and 11.24 respectively, and the average was 20.27 per cent. These data show that delayed chopping or chopping early and thinning to one stalk per hill significantly increased the damage. Apparently the delayed chopping favored an increase in the thrips population on the larger and more abundant weed growth among the cotton. The stunting effect of the larger weeds on cotton seedlings might also have contributed to the increased damage. Where only one stalk was left in the hill the increased damage was possibly due to a greater concentration of these insects on the remaining plants after chopping.

Table 2.—Percentage of bolls set by 40 varieties of cotton, as recorded weekly, Stoneville, Miss., 1936.

Date	Accumulative Percentage of Boll Production	
	Normal Plants	Damaged Plants
June 23–29	16.24	11.34
June 30–July 6	53.91	32.23
July 7–13	74.63	48.99
July 14–20	86.51	69.66
July 21–27	93.37	82.96
July 28–Aug. 3	95.2	87.26
August 4–10	97.09	93.30
August 11–17	99.68	99.39
August 18–24	100.	100.

Table 2 records the percentages of bolls set at weekly intervals throughout the fruiting season.

These data show that the average crop of bolls was set more rapidly on the normal plants. Approximately 10 days intervened from the time that 74.63 per cent of the bolls had set on the normal plants until an equal percentage had set on the thrips-damaged plants. Approximately 14 days elapsed between the time 93.37 per cent of bolls had set on the normal and damaged plants.

An average loss of 7.72 per cent in the number of bolls and of 13.38 per cent in seed cotton was shown by the damaged plants as compared with normal plants.

Commercial classing of lint showed that none of the samples from the damaged plants were of higher grade than the samples from normal plants of the same varieties, and in seven varieties there was a loss of one thirty-second of an inch in staple length.

Discussion.—The numbers of seedlings per plot before chopping were unequal, since the viability of seed among the varieties showed great variation. Since it is shown that the number of stalks in the hill influenced the amount of damage it is not logical to attribute any variation in damage to varietal resistance. The type of terminal bud in different varieties, however, may have some effect on the damage and warrants further study.

The damaged plants of all varieties produced their crop of bolls later in the season, and 26 of the 40 varieties showed a decrease in the numbers of bolls produced. Two varieties produced the same number of bolls on both injured and normal plants, but in an equal number of bolls on both types of plants less seed cotton was produced by the damaged plants. The other 12 varieties produced a greater number of bolls on the damaged plants. Six of these showed a loss in seed cotton production and the other six showed a slight gain in seed cotton. Of the 40 varieties under observation, 34 produced less seed cotton on the damaged plants than on the normal plants.

Since in the entire experiment the average seed cotton loss (13.38 per cent) was nearly twice the loss in boll production (7.72 per cent), it is seen that the average size of the bolls was reduced in the damaged plants.

In these observations the factor of boll weevil damage was entirely eliminated because of no infestation. It is difficult to estimate what would have been the comparative cotton loss under heavy weevil damage, but it appears almost certain that the percentage loss would have been much greater in the damaged plants, since their bolls were produced later in the season than were those on the normal plants. It is a well-known fact that under conditions of heavy weevil infestation a crop may be seriously influenced by just a few days' delay in the maximum fruiting period. It may be of interest to know that one of the fast-fruiting varieties produced 75 per cent of its crop on the normal plants by July 5, whereas for a slow-fruiting variety an equal percentage was not produced until July 28. There was a tendency for the bud damage to delay the fruiting period longer for the fast-fruiting varieties than for the others.

Summary.—In this study of thrips injury to 40 varieties of cotton it was found that early chopping and allowing a greater number of stalks to the hill decreased the percentage of terminal bud damage. No difference in varietal infestation was observed under the conditions of the experiment.

The average boll crop for all varieties was reduced 7.72 per cent and was set from 10 days to two weeks later on the damaged plants than on the normal plants. The average loss of 13.38 per cent in seed cotton showed that there was also a decrease in the size of bolls produced by the damaged plants. Destruction of the terminal buds caused a loss in seed cotton production in 34 of the 40 varieties.

Commercial classification of the lint showed a loss in staple length on damaged plants of seven varieties.—3-15-37.

Species of Thrips Found on Cotton in South Carolina

J. G. WATTS, *South Carolina Agricultural Experiment Station, Clemson*[1]

Thysanoptera damage to cotton in the south is usually referred to collectively as "thrips injury" without discrimination and often without a knowledge of the species involved. In many cases a knowledge of the species present may be of no significant importance since control measures for one will be equally effective against certain others, but in other instances it may be highly desirable to know the species involved when it is remembered that *Frankliniella fusca* (Hinds) requires approximately five days more to complete its development than does its close relative *F. tritici* (Fitch) (Watts 1936), and when it is realized that still greater differences may exist among other important species whose life histories

[1] Technical contribution 48 from the Entomology Department, South Carolina Agricultural Experiment Station.

are not known. Possible differences in resistance to control measures and differences in adaptability to various cotton varieites of the several economic species may, when thoroughly studied, prove even more important than any differences which may exist in developmental periods.

The number of species of thrips on cotton is probably greater and more varied than on any other farm crop grown in South Carolina. A total of 13 species has been found representing 10 genera belonging to three families and two suborders.

Frankliniella tritici (Fitch), the flower thrips, more than equaled the total population of all other species on cotton between the years 1931 to 1935 inclusive, but in 1936 it was the third most abundant. This species is primarily a flower-feeding form and past reports of its injury to plants other than cotton, such as roses, carnations, strawberries, beans, etc., have been largely on the flowering parts. The injury to seedling cotton is done by both adults and larvae, but the latter are usually more abundant and probably do more damage. Large numbers of both adults and larvae are almost invariably present in the cotton blossoms but no resulting damage has ever been observed. The life history and habits of this species have been worked out and reported (Watts 1936).

Frankliniella fusca (Hinds), the tobacco thrips, was first known as a pest of shade-grown tobacco about 1904 but in more recent years has become one of the more important thrips on cotton. This species, which ranks about second in importance, is found regularly on cotton in moderate abundance, seldom occurring in sporadic outbreaks. It is usually the first species to migrate to the cotton seedlings in the spring, where injury is indistinguishable from that of *tritici*. On the mature plant *fusca* is found not in the blossoms but on the under surface of the leaves, where its feeding does not result in any evident injury. Feeding is restricted almost exclusively to the leaves of its host plants, which hosts are neither as extensive nor as diversified as those of *F. tritici*. The life history and habits on tobacco were reported by Hooker (1905), and on cotton by Eddy & Livingston (1931) and the writer (Watts 1936).

Frankliniella williamsi Hood is not considered an economic species at present because of its limited population, but there is a possibility of its becoming of importance if optimum weather conditions for its development should occur. It commonly occurs on cotton where its feeding habits are very similar to those of *fusca*. The host plants are also fewer and the distribution more limited than is the case with *fusca*. To the writer's knowledge, no work on the life history of this species has been published.

Thrips tabaci Lind., the onion thrips, is probably the most indiscriminate of plant-feeding Thysanoptera, having been recorded from a wide range of unrelated plants, and is practically world-wide in distribution. It is regularly found on cotton, but is rarely if ever the most important species in the southern states. The writer has no knowledge of its relation to more mature cotton grown under irrigation in the West, but in Europe it is reported (MacGill 1927) to become at times quite a serious pest. The life history of this species has been worked out and reported on probably more than any other thrips.

Thrips panicus Moulton was described in 1929 from Cuba and Hawaii

and probably is now for the first time reported from the United States. Specimens identified as this species by Dudley Moulton of California were taken on cotton in 1936 at Walterboro, S. C., which lies in the southern part of the state about 30 miles from the coast. It was present in rather small numbers and may have been of limited local importance. Nothing is known of its life history.

Sericothrips variabilis (Beach) was present on cotton in South Carolina from 1931 to 1935, inclusive, in unimportant numbers, but in 1936 it constituted about 75 per cent of the entire population, which caused rather serious damage in the eastern half of the state. It was the predominating species in every cotton field examined in 21 counties, but extensive injury was not present in all cases. It has been found on quite a variety of plants, and from past experience it apparently requires a restricted combination of climatic conditions in order to develop in abundance. Apparently this thrips has been of little economic importance in previous years because its name has seldom appeared in literature among the economic forms. The writer has under way at the present time a study of the life history of this species.

Echinothrips americanus Morgan is primarily a greenhouse thrips and is seldom found on cotton in the field, but on one occasion a heavy infestation developed on half-grown cotton which was caged in soil tables at Clemson, S. C. The infestation was allowed to develop and in a few weeks all the plants were killed.

Limothrips cerealium Haliday occurs throughout the eastern half of the United States, in Europe, northern Africa and the Hawaiian islands, mostly on grasses and small grains on which it is known to develop. Its occurrence on cotton is almost invariably as an adult insect in fields or areas adjacent to small grain. Its typical food habits are such that it is not likely to become a cotton pest.

Anaphothrips obscurus (Mull.), commonly known as the northern grass thrips, is scarce in South Carolina and is only an occasional visitor of the cotton plant.

Aeolothrips bicolor Hinds is reported (Russell 1912) to be predaceous on the onion thrips, but is also very likely a plant feeder in addition. It is found mostly on grasses and occasionally on cotton.

Stomatothrips flavus Hood is rare in South Carolina and the only record of its occurrence is on cotton. Taxonomically it is related to the preceding species and probably also has similar food habits.

Leptothrips mali (Fitch) is a solitary species occurring on many trees, shrubs and herbs. It is commonly known as the "black hunter" and is reported (Treherne 1918) to be predaceous on other thrips and small insects. It is occasionally found on cotton.

Liothrips sp. was taken once from cotton but very likely was an accidental visitor.

From the 13 species listed, four can be pointed out as causing appreciable injury to cotton at irregular intervals: *F. tritici*, *F. fusca*, *T. tabaci* and *S. variabilis*. *F. williamsi* might be regarded as a potential source of injury since it is frequently found on cotton and its habits and injury are practically identical with the other economic species mentioned. *T. panicus*, though only recently found on cotton, is a close relative of

and has habits similar to certain economic species, and is therefore in a doubtful status. None of the seven remaining species are likely to become of economic importance on cotton.—3-4-37.

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Reduction of Cotton Yield by Thrips

J. G. Watts, *South Carolina Agricultural Experiment Station, Clemson*[1]

Thrips injury to cotton is a subject relatively new in entomological literature, and it is believed that its importance is not fully known and appreciated. In the United States thrips injury to cotton might be considered as falling in two natural groupings: (1) injury to the mature plant from which recovery is limited and which occurs in the west where all of the cotton is grown under irrigation, and (2) injury restricted to seedlings and small plants resulting in an excessively branched mature plant and which occurs in the eastern half of the cotton belt. It is the latter type of injury with which this paper deals.

To emphasize the suddenness and short duration of thrips attacks the season of 1936 is briefly reviewed. The thrips injury to cotton during the 1936 season, which was no exception, was done in an astonishingly short time. Recorded in field notes of May 4 was mention of the occurrence of only scattered adults on young seedlings, but by May 13 larvae were abundant and doing serious damage. By May 20 the population had begun to diminish and after that date there was very little damage.

Research workers as well as farmers have often asked if thrips actually cause any reduction in cotton yields. With no definite experimental information at hand relative to this question, a dependable answer could not be given. It had been taken for granted that feeding of the hordes of thrips which often frequent young cotton seedlings would in all probability result in a reduction of cotton yields. On the other hand stalks injured by thrips apparently overcome the resulting stunted condition to a large extent by the time fruiting has begun. To determine whether or not any ultimate loss results the following experiment was set up.

A field which was heavily infested with thrips and showed signs of serious thrips injury was selected in which to lay out the experiment. In

[1] Technical contribution 47 from the Entomology Department of the South Carolina Agricultural Experiment Station.

this field a representative area was selected in which were staked and numbered 100 stalks that had been severely injured by thrips. A stalk was considered to have been severely injured when the terminal bud of the seedling had been killed back so that two or more main branches grew out instead of one. Beside or very close by each injured stalk, a stalk with as little injury as possible was selected as a check, thus making a total of 200 stalks under observation. A daily examination for white blooms was made throughout the blossoming season which for this particular field covered the period from June 20 to August 18. The first white blossoms appeared on the normal stalks June 20; on June 30 they appeared on stalks injured by thrips. The last white blossoms appeared

Table 1.—Blossoming records on normal cotton and cotton severely injured by thrips, Florence, S. C., 1936, showing seasonal distribution of blossoms and per cent of the total open to last date.

Date	100 Normal Stalks		100 Thrips-injured Stalks	
	No. Blossoms	Per Cent Open to Last Date	No. Blossoms	Per Cent Open to Last Date
June 11–20	2	.045	0	0.
June 21–30	229	5.26	1	.035
July 1–10	937	26.59	346	12.11
July 11–20	1764	66.77	1176	53.16
July 21–31	1414	98.98	1240	96.44
August 1–10	44	99.99	102	100.
August 11–20	1	100.		
Total blossoms	*4391*		*2865*	

August 11 on the normal stalks and August 10 on the thrips-injured stalks. On 50 days there were white blooms on the normal stalks but blooms continued on thrips-injured stalks only 42 days, table 1.

It was found that the injured series was 10 days later than the normal series in putting on the first blooms, that the injured series bloomed on eight days less than the normal plants, and that they both stopped blooming at approximately the same time. Aside from the delay in blooming quite a number, but by no means all, of the mature plants in the injured series were decidedly below average in vitality. This in all probability was due mostly to starvation because of the deprivation of soil nutriment as well as sunlight by the uninjured healthy plants. There is also the possibility of a resulting toxic substance in the plant because of excessively heavy feeding by thrips. The reduced vitality together with delay in fruiting resulted in the injured series opening only 65 per cent as many blossoms as the uninjured.

It becomes evident at once, therefore, that when cotton is severely injured by thrips and delayed in its fruiting for 10 days or more, the boll weevil issue becomes of more importance. In average and severe boll weevil years the delay in fruiting caused by thrips injury becomes of particular importance because much of the late fruit that otherwise would mature is destroyed by the boll weevil. The control or suppression of thrips would, therefore, become one of the first steps in reducing the amount of boll weevil loss.

Following the completion of the data on bloom counts, complete records on boll and seed cotton production were kept on the injured and uninjured series of plants. Weights of the seed cotton were made in grams to facilitate accuracy in making small weights but the total is also given in pounds. Production records are presented in table 2.

Table 2.—Boll and seed cotton production on normal plants and on plants severely injured by thrips, Florence, S. C., 1936.

	100 Normal Stalks		100 Thrips-injured Stalks	
	No. Bolls Maturing	Grams of Seed Cotton	No. Bolls Maturing	Grams of Seed Cotton
1st picking August 19	378	2428	34	136
2nd picking August 28	603	3812	294	1729
3rd picking September 10	930	4176	693	3657
4th picking October 5	115	416	195	895
Total bolls and seed cotton	*2026*	*10832* (*23.88 lbs.*)	*1216*	*6417* (*14.14 lbs.*)
Average number bolls per stalk	20.26		12.16	
Average weight per boll, grams	5.346		5.277	
Per cent total blooms producing-bolls	46.14		42.44	
Calculated production, pounds per acre*	4432		2630	

* This calculation was figured on the basis of 18,600 stalks per acre. The actual production was 2840 pounds per acre for "field run" cotton.

From the production data it was found that the injured series produced only 60 per cent as many mature bolls as the uninjured series. From a similar observation Gaines (1934) reported 56 per cent more bolls on uninjured cotton than on injured stalks. Likewise there was only 59 per cent as much seed cotton on the injured as on the uninjured series. The average weight per boll from the uninjured series was found to be .069 gram more than those from the injured series, but this difference may or may not be significant. A proportion based on the production of 100 stalks in the uninjured series showed that 18,600 stalks, or an acre, would produce 4432 pounds, while the same calculation for the thrips-injured series showed the production per acre to be only 2630 pounds. The actual production in this field was 2840 pounds per acre on $5\frac{1}{2}$ acres.

In presenting these data it should be pointed out that the plants in the series referred to as "normal" received a certain amount of thrips injury, as did virtually every stalk in the field, but the injury was not to the extent of killing the terminal bud in the seedling stage. Had the check or normal series been entirely free from thrips the difference in production in all probability would have been even greater.

In the field from which these data were taken 56 per cent of the terminal buds had been killed in the seedling stage, as determined from a count of approximately 9000 plants from 200 feet of row at each of 30 points in the field. It is concluded, therefore, that 56 per cent of the plants in this field would have produced approximately 40 per cent more cotton in the absence of thrips injury.—3-4-37.

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Leafhoppers Found on Cotton

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In this paper are recorded observations which have been made in the vicinity of College Station, Tex., during the last 10 years. All of the records are from cotton growing in the Brazos river bottoms of Brazos and Burleson counties, or from cotton growing on the upland near College Station in Brazos county. These records of leafhoppers have been made incidental to other investigations of insects affecting cotton and no claim is made that they are complete.

The following list of leafhoppers is arranged in the order given in the "Catalogue of the Hemiptera of America North of Mexico," by Edward P. Van Duzee. The months given are those in which the species has been taken on cotton. No nymphs were reared to maturity. Nymphs are recorded as present only when abundant and closely associated with adults.

Agallia constricta Van D., May, Aug. Bottomland. Not common in cotton but plentiful in alfalfa in nearby fields. *A. uhleri* (Van. D.), May, Sept. Bottomland. Not common in cotton; plentiful in alfalfa. *Bythoscopus robustus* (Uhl.), Aug., Sept. Not common but widely distributed in both upland and bottomland cotton. *Oncometopia undata* (Fabr.), June to frost. Common, upland and bottomland. Nymphs present. *O. lateralis* (Fabr.), June to frost. Common upland and bottomland. Nymphs present. *Homalodisca triquetra* (Fabr.), June to frost. Common upland and bottomland. Nymphs present. *Aulacizes irrorata* (Fabr.), June to frost. Common, upland and bottomland. Nymphs present. *Kolla hartii* Ball, July, Aug., bottomland, not common. *Graphocephala versuta* (Say), May to frost. Very abundant in bottomland cotton. Nymphs present throughout season. *Draeculacephala mollipes* (Say), July, Aug., Sept. Common in bottomland cotton. *Carneocephala flaviceps* (Riley), June to frost. Common. This species is extremely abundant on Bermuda grass in both bottoms and upland. *Gypona octolineata* (Say), July, Aug. Adults not common. Bottomland. Nymphs found occasionally which appear to belong to this species. *Nasutoides frontalis* (Van D.), July, Aug., Sept. Bottomland. Not abundant but widely distributed. *Exitianus obscurinervis* (Stal.), June to frost. Common on cotton. Bottomland and upland, very abundant on Bermuda grass. *Eutettix seminudus* (Say), June, July, Aug. Bottomland. Not common but widely distributed. *Phlepsius excultus* (Uhl.) Aug. Bottomland. Not common. *P. irroratus* (Say), Aug., Sept. Bottomland. Not common. *Chlorotettix viridius* Van D., July, Aug. Bottomland. Not common. *Cicadula sexnotata* (Fall.), Aug. Bottomland. Not common. *Eugnathodus abdominalis* (Van D.) July, Aug. Bottomland. Not common. *Empoasca fabae* (Harris), April throughout season. Common, especially near alfalfa fields in bottom. This leafhopper is the earliest which has been found on cotton.

In addition to the foregoing Cicadellidae the membracid *Stictocephala festina* (Say) has been frequently taken on bottomland cotton. This insect is very common on field peas and alfalfa in the bottom. The Fulgoridae *Dictyophora microrhina* Walk. and *Acanalonia conica* (Say) have also been taken.

While the well-known "sharpshooters," *Oncometopia undata*, *O. lateralis*, *Homalodisca triquetra* and *Aulacizes irrorata* are wide-spread and common on cotton, the leafhopper *Graphocephala versuta* has been observed to be the most plentiful within certain areas. During the past few years this insect has been extremely abundant, both nymphs and adults, on cotton. Dr. F. L. Thomas, Texas Agricultural Experiment Station, has reported it as very abundant on cotton in the coastal region of Texas. All five of these leafhoppers were observed feeding on squares and small stems.

Leafhoppers were found to be more abundant as to species and numbers in the rankest cotton. They are usually much more abundant in the bottoms than in the upland.

It is probable that most of the species recorded in the foregoing list are present in cotton accidentally. However, when we remember the feeding habits of these insects and the fact that some species of Cicadellidae are known vectors of virus diseases we are forced to consider them as possible sources of danger to the growing of cotton.—3-4-37.

Toxicity of a Number of Insecticides to Three Cotton Insects

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The cage toxicity tests discussed in this paper were made at Tallulah, La., during the summer of 1936 to test the efficacy of various insecticides and mixtures of insecticides under cage conditions. Promising insecticides and combinations were tested later under field conditions, while the ones that were not promising were discarded.

Methods.—Cages measuring 4 by 4 by 4 feet, covered with 16-mesh galvanized screen wire, were used for tests with the boll weevil, *Anthonomus grandis* Boh., and the cotton leaf worm, *Alabama argillacea* Hbn. Cages measuring 18 by 18 by 24 inches, covered with 24-mesh copper wire, were used for tests with the tarnished plant bug, *Lygus pratensis* L. In all the tests the cages were placed upon platform bottoms supported by legs placed in pans of water in order to make the cages ant-proof. Each cage was placed over one plant which was coated with a sticky material near the base to prevent ants from climbing it. In the boll weevil and leaf worm tests cotton plants were used, and in the *Lygus pratensis* tests cotton, dog-fennel, *Maruta cotula* L. and *Erigeron annuus* L. were used. In the tests with boll weevils and leaf worms 25 insects were used per cage and in the tests with *Lygus pratensis* 50 were used per cage.

[1] The authors were assisted in the field by C. A. Richmond, G. C. Woodruff and W. R. Stanley

In all cases the insects were introduced into the cages late in the afternoon, and applications of poison were made early the following morning, usually between 5 and 6 a.m., with small plunger-type hand dusters. An effort was made to apply all the insecticides at approximate field dosages of 4 to 6 pounds per acre. Examinations of the cages to determine the number of dead insects were started at 11 a.m. on the day on which the poisons were applied. A second examination was made on

Table 1.—Cage toxicity tests against the boll weevil with 20 brands of commercial calcium arsenates.

Sample No.	Per Cent Water-soluble As_2O_5 By N.Y. Method	By A.O.A.C. Method	Per Cent Total As_2O_5	Density, Cu In. per Lb.	Per Cent Mortality	Per Cent Control
ID3174	11.5	.18	43.57	42	92	90
3171	6.4	.11	42.87	68	83	78
3197	7.6	.11	41.21	60	81	76
3191	.5	.04	45.34	69	80	75
3215	6.8	.08	42.31	81	77	70
3220	4.2	.08	45.31	78	77	70
3207	3.5	.15	46.38	69	76	69
3201	8.7	.08	40.19	57	76	69
3214	6.1	.08	42.19	72	76	69
3204	3.2	.30	41.52	93	75	68
3216	.7	.08	42.81	84	71	63
3210	1.9	.05	42.02	69	70	61
3208	6.	.11	41.00	74	68	59
3205	7.9	.09	41.99	64	66	56
3202	6.3	.08	40.98	66	66	56
3353	.6	.23	43.29	78	66	56
3211	1.	.15	40.77	72	62	51
3206	3.2	.11	43.26	78	57	45
3203	.2	.08	40.71	111	53	40
3209	.6	.11	43.14	48	39	21
Checks					22	

the same day at 4 p.m. During the second day three examinations were made and on the third and fourth days two examinations each were made. After tests were completed the plants and cages were thoroughly examined for live insects.

The mortality figures were computed upon the basis of dead and live insects observed during the period of the tests and not upon the numbers introduced, for in spite of all the precautions taken, ants removed some of the insects from the cages, especially in the tests with nymphs and adults of *Lygus pratensis*. The figures on the average percentage of mortality are based on two to 11 series of tests with each group of insecticides. The per cent of control (Tate & Andre 1936) was computed by using the formula $\frac{(x-y)\ 100}{x}$, with x the percentage of live insects in the check cages and y the percentage alive in the treated cages.

Discussion of tests.—Table 1 presents the results in tests with 20 different brands of commercial calcium arsenate. The chemical analyses were made by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine. The percentage of water-soluble

As_2O_5 as determined by the New York method, discussed by Pearce, Norton and Chapman (1935) and by the Association of Official Agricultural Chemists method, and the total As_2O_5 are given for comparison. It will be noted that the variation in the percentage of boll weevil mortality in tests with the various brands of calcium arsenate was considerable, the range being between 92 and 39 per cent. No burning of the cotton plant was experienced with any of these calcium arsenates with dosages ordinarily used in the field, but in the plant tests with excessive dosages a trace of burning was noted with some of the samples with the highest percentage of water-soluble As_2O_5.

Table 2.—Cage toxicity tests against boll weevil and leaf worm with various insecticides and combinations.

Treatment, Percentages	Per Cent Mortality		Per Cent Control	
	Boll Weevil	Leaf Worm	Boll Weevil	Leaf Worm
Calcium arsenate–sulfur 50:50	66	85	53	84
Calcium arsenate–sulfur $33\frac{1}{3}:66\frac{2}{3}$	68	84	56	83
Calcium arsenate–sulfur 20:80	59	72	44	71
Calcium arsenate–lime 50:50	68	89	57	88
Calcium arsenate–lime $33\frac{1}{3}:66\frac{2}{3}$	52	74	35	73
Calcium arsenate–lime 20:80	55	62	38	60
Calcium arsenate–clay 50:50	61	86	47	85
Calcium arsenate–clay $33\frac{1}{3}:66\frac{2}{3}$	46	88	27	88
Calcium arsenate–clay 20:80	41	69	19	68
Lead arsenate–sulfur 50:50	57	88	42	88
Lead arsenate–sulfur $33\frac{1}{3}:66\frac{2}{3}$	54	84	37	83
Lead arsenate–sulfur 20:80	45	85	25	84
Calcium arsenate–cubé 80:20	70	89	59	88
Lead arsenate	68	82	56	81
Calcium arsenate No. 1*	74	92	65	92
Calcium arsenate No. 2*	85	91	79	91
Checks	27	5		

* Calcium arsenate No. 1, containing 38.3 per cent total As_2O_5 and 4.1 per cent water-soluble As_2O_5 by A.O.A.C. method, was used in the sulfur and cubé mixtures, while calcium arsenate No. 2, containing 42 per cent total As_2O_5 and 1 per cent water-soluble As_2O_5 by A.O.A.C. method, was used in the lime and clay mixtures. Calcium arsenate No. 1 and ID 3197 were manufactured by the same firm. Calcium arsenate No. 2 and ID 3171 were manufactured by another firm.

Calcium arsenate mixed with sulfur caused a slightly higher mortality of boll weevils than comparable mixtures of calcium arsenate with lime or with clay, table 2. Lead arsenate mixed with sulfur caused about the same mortality as calcium arsenate mixed with lime and calcium arsenate mixed with clay, but slightly less mortality than mixtures of calcium arsenate and sulfur. Lead arsenate mixed with sulfur caused a slightly higher mortality of leaf worms than calcium arsenate mixed with either sulphur, lime or clay. There was very little difference in leaf worm mortalities caused by calcium arsenate mixed with sulfur, lime or clay. Undiluted calcium arsenates caused a somewhat higher mortality of boll weevils and of leaf worms than undiluted lead arsenate. The highest mortalities in this series of tests against both insects were caused by undiluted calcium arsenate.

Mixtures of calcium arsenate and Paris green, table 3, killed a higher percentage of boll weevils than undiluted calcium arsenate and a smaller

percentage than undiluted Paris green. Lower mortalities were caused by calcium arsenate–sulfur mixtures and by Paris green–sulphur mixtures. Undiluted calcium arsenate and undiluted Paris green killed a higher percentage of leaf worms than did mixtures of calcium arsenate–Paris green, calcium arsenate–sulfur, and Paris green–sulfur. Mixtures of Paris green–sulfur killed a higher percentage of *Lygus pratensis* nymphs than mixtures of calcium arsenate–Paris green and mixtures of calcium arsenate–sulfur. Undiluted Paris green killed a higher percentage of nymphs than any of the mixtures. Mixtures of calcium arsenate–Paris green killed a higher percentage of *Lygus pratensis* adults than mixtures of calcium arsenate–sulfur and mixtures of Paris green–sulfur. Mortalities were about equal for mixtures of calcium arse-

Table 3.—Cage toxicity tests against the boll weevil, leaf worm and *Lygus pratensis* with mixtures of calcium arsenate–Paris green, calcium arsenate–sulfur and Paris green–sulfur, and the three chemicals used alone.

Treatment, Percentages	Per Cent Mortality				Per Cent Control			
	Boll Weevil	Leaf Worm	*Lygus pratensis* nymphs	*Lygus pratensis* adults	Boll Weevil	Leaf Worm	*Lygus pratensis* nymphs	*Lygus pratensis* adults
Calcium arsenate*–Paris green 75:25	84	90	54	54	80	89	36	30
Calcium arsenate*–Paris green 90:10	79	78	62	59	74	77	48	37
Calcium arsenate*–Paris green 95:5	84	87	49	60	80	87	30	38
Calcium arsenate*–sulfur 50:50	66†	85‡	44	53	53†	84‡	23	28
Calcium arsenate*–sulfur 33⅓:66⅔	68†	84‡	34	50	56†	83‡	10	23
Calcium arsenate*–sulfur 20:80	59†	72‡	47	48	44†	71‡	28	21
Paris green–sulfur 10:90	58	79	75	54	47	78	66	30
Paris green–sulfur 7.5:92.5	56	74	61	45	45	74	46	16
Paris green–sulfur 5:95	50	76	66	52	37	75	53	26
Paris green	89	91	77	83	86	91	69	74
Calcium arsenate* No. 2	77	91			70	90		
Sulfur			47	38			27	5
Checks	21	3	27	35				

* Calcium arsenate No. 1 was used with the Paris green and sulfur, calcium arsenate No. 2 alone. See footnote below table 1.

† Checks for these test 26.55 per cent. ‡Checks for these tests 5.05 per cent.

nate–sulfur and mixtures of Paris green–sulfur. Paris green, undiluted, killed a much higher percentage of *Lygus pratensis* adults than when mixed with calcium arsenate or sulfur. Sulfur alone killed a higher percentage of *Lygus pratensis* nymphs than adults, but the percentage of mortality was low in both cases. Mixtures of calcium arsenate with 5 and 10 per cent Paris green caused a trace of burning of the cotton plant, while 25 per cent of Paris green with calcium arsenate as well as undiluted Paris green caused light burning. Mixtures of sulfur and 5, 7.5 and 10 per cent Paris green caused severe plant burning, and 5 per cent mixture being a little more severe than undiluted Paris green.

Tests were planned to compare derris, cubé, and Devil's shoestring containing equal amounts of rotenone in mixtures with sulfur. The mixtures were prepared, however, before the analyses were received, and the rotenone contents of the mixtures are only approximately equal.

Cubé containing 4.9 per cent of rotenone, table 4, produced a higher mortality of boll weevils than derris containing 3.9 per cent of rotenone, Devil's shoestring (1.7 per cent of rotenone), or calcium arsenate. The mortality from calcium arsenate, however, was higher than that from derris, Devil's shoestring or mixtures of cubé, derris and Devil's shoe-

Table 4.—Cage toxicity tests against boll weevil and leaf worm with derris, cubé and Devil's shoestring.

Treatment, Percentages	Per Cent Mortality		Per Cent Control	
	Boll Weevil	Leaf Worm	Boll Weevil	Leaf Worm
Derris–sulfur 40:60 (rotenone 1.56)	49	64	40	62
Derris–Sulfur 20:80 (rotenone .78)	39	56	27	54
Derris–sulfur 10:90 (rotenone .39)	28	41	14	39
Cubé–sulfur 40:60 (rotenone 1.96)	53	73	45	72
Cubé–sulfur 20:80 (rotenone .98)	39	60	28	58
Cubé–sulfur 10:90 (rotenone .49)	21	33	6	31
Devil's shoestring–sulfur 94:6 (rotenone 1.6)	37	39	25	37
Devil's shoestring–sulfur 47:53 (rotenone .8)	38	40	26	38
Devil's shoestring–sulfur 23.5:76.5 (rotenone .4)	31	41	18	39
Derris (rotenone 3.9, total extractives 11.6)	72	78	67	77
Cubé (rotenone 4.9, total extractives 17)	83	77	80	76
Devil's shoestring (rotenone 1.7, total extractives 7.5)	37	46	26	44
Calcium arsenate No. 2	77	89	73	89
Checks	16	3		

string with sulfur. Calcium arsenate caused a higher mortality of leaf worms than did either derris, cubé or Devil's shoestrong, used alone or in mixtures with sulfur.

Pyrethrum containing .76 per cent total pyrethrins, table 5, and mixtures of pyrethrum with sulfur, Paris green and cubé did not kill as high a percentage of boll weevils as did calcium arsenate. Pyrethrum produced about the same mortality of leaf worms as calcium arsenate, and both were much more effective than the mixtures of pyrethrum. Pyrethrum

Table 5.—Cage toxicity tests against boll weevil, leaf worm and *Lygus pratensis* with pyrethrum and pyrethrum mixtures.

Treatment, Percentages	Per Cent Mortality				Per Cent Control			
	Boll Weevil	Leaf Worm	*Lygus pratensis* nymphs	*Lygus pratensis* adults	Boll Weevil	Leaf Worm	*Lygus pratensis* nymphs	*Lygus pratensis* adults
Pyrethrum–Paris green–sulfur 10:5:85	45	82	50	59	24	81	30	32
Pyrethrum–Paris green–sulfur 10:10:80	48	76	62	61	29	75	47	36
Pyrethrum–Paris green–sulfur 20:5:75	38	67	69	61	14	65	57	35
Pyrethrum–Paris green–sulfur 20:10:70	51	82	65	62	33	81	51	36
Pyrethrum–cubé–sulfur 10:10:80	34	65	79	52	9	63	71	21
Pyrethrum–sulfur 40:60	36	74	74	78	12	73	63	63
Pyrethrum (.76 total pyrethrins)	37	92	90	88	14	92	86	80
Calcium arsenate No. 2	75	92			66	92		
Sulfur			70	41			58	3
Checks	27	5	29	40				

(.76 pyrethrins) produced the highest mortality of adults and nymphs of *Lygus pratensis* of any insecticide tested, and in mixtures with sulfur or sulfur and cubé caused fairly high mortalities.

Summary.—Against the boll weevil calcium arsenate was more effective than any of the insecticides tested with the exception of cubé (4.9 per cent rotenone), Paris green and mixtures of calcium arsenate–Paris green. Against the leaf worm calcium arsenate caused about the same

mortality as pyrethrum (.76 per cent total pyrethrins), Paris green or mixtures of calcium arsenate–Paris green. Against nymphs and adults of *Lygus pratensis* pyrethrum (.76 per cent pyrethrins) and Paris green caused the highest mortalities. Pyrethrum and pyrethrum mixtures with sulfur, Paris green and cubé are promising insecticides against this insect.—3-15-37.

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Sorghum Webworm Studies in Texas

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Although known in this country for more than half a century, the sorghum webworm, *Celama sorghiella* Riley, has proved destructive in but limited areas of its geographical range and perhaps for this reason has not been frequently mentioned in economic literature. It is one of the major pests that attack grain sorghums in Texas, and, during wet seasons, which appear most favorable for rapid increase, the insect frequently becomes a limiting factor in the profitable production of these crops. Serious losses have been experienced by growers throughout the eastern half of the state, but hitherto the species has not become established in the subhumid region of northwest Texas, where grain sorghums are grown extensively.

Prior to 1932, little if any information based on detailed observations was available concerning the sorghum webworm; also by this time complaints of injury were definitely increasing, and for these reasons biological observations of the insect were begun at College Station. The studies were continued during the seasons 1933–34, inclusive, and it seems desirable to make available some of the principal findings with reference to the biology of the species.

Food plants.—The present list of known food plants of the sorghum webworm includes a variety of species, all members of the grass family. The larvae feed upon the seed of grain sorghums in general, but the varieties characterized by compact seed heads as in case of milo, hegari, feterita, etc. seem preferred. The worms likewise attack the seed of sweet sorghums, broom corn, Sudan and Johnson grass, and occasionally the silks and tassel of corn. There are probably other native grasses which support the insect, and in the northern part of its geographical range rye and timothy have been listed as food plants. In Texas, however, grain sorghum is the principal crop to suffer extensive injury. Seed in the milk and dough stage of development seems most attractive to the larvae and upwards of 70 per cent of the grain may be injured or destroyed in fields where heavy infestations occur.

Life history and habits.—The life cycle of the sorghum webworm may be briefly considered in the order of the adult and its three developmental stages, which as usual include the egg, the larva and the pupa.

The adult is a small whitish moth with a wing expanse of 12 to 16 mm. The upper surface of the forewing is irregularly mottled with yellow and brown, and near the costal margin bears three characteristic tufts of suberect blackish scales. The hind wings are pure white above and below. The moths are nocturnal in habit or are more active at night. Beginning shortly after dusk they may be observed in the field making short, rapid or dartlike flights from plant to plant. During the daytime they are generally less active and remain inconspicuous by resting motionless in protected situations for periods of half a day or longer. Egg-laying activities of the moths also occur mainly over night. The eggs are deposited singly and usually on the flowering parts or seed of the food plant. Oviposition may begin within the first 24-hour period of adult activity. Records on the number of eggs laid in the laboratory indicate a maximum of 169 for one individual, but dissections of females at the end of their oviposition period indicate that the total number laid per individual under field conditions may be considerably greater. The longevity of adults in close confinement, when supplied with moisture, ranged up to 23 days.

Egg.—When first laid, the eggs are white with a pale greenish yellow tinge, but change to straw yellow within a day or two and to a deeper yellow or brown as the embryo approaches complete development. In size, they are slightly variable, averaging a trifle less than .5 mm. in diameter. Viewed from above, the egg is roundish to broadly oval and flattened dorsoventrally, so that its height barely exceeds one-half the maximum diameter. The shell is thick and under magnification shows characteristic pentagonal and hexagonal reticulations. In mean temperatures of 80° F or above, the eggs hatch in three to four days, but in lower temperatures during the early and latter parts of the growing season the incubation period is increased to five or six days.

Larva.—A total of 206 larvae representing five generations were reared to maturity under laboratory conditions from May 10 to September 26, 1932. Four to seven larval stages were observed between the time of hatching and pupation. Most individuals, however, attained full growth by the end of the fifth instar, indicating that usually five molts occur during larval development. Based on the mean duration of the five normal instars, the time required for larval development was about 13.5 days. During the first four developmental stages the larvae molted after approximately equal feeding periods, which averaged slightly over 2.5 days. Normally, the fifth larval instar includes the prepupal period and is therefore somewhat more protracted than the preceding ones. When newly hatched, the larvae commonly feed for a time upon the succulent and tender flowering parts of the sorghum plant, but begin to show a preference for the nutritious contents of the seed. In the latter instars they are voracious feeders and in cages single individuals may consume the greater part of a dozen or more seeds in a 24-hour period. Larvae were not observed to spin any webs for protection during the feeding or molting activities. The mature larva is rather

depressed, greenish and marked with four longitudinal reddish to black dorsal stripes. The surface of the body bears numerous wartlike tubercles above, which are thickly beset with sharp-tipped spines and long slender hairs. The measurements of the larva range from 9 to 14 mm. in length and 3 to 4 mm. in width. Before entering the prepupal stage the larva spins upon the food plant a white silken cocoon within which pupation occurs.

PUPA.—A total of 523 pupae, including five generations, were reared. These records show that the time required for transformation to the adult is subject to considerable variation. This was true even among individuals which pupated on the same day and developed under the same environmental conditions. The duration of the pupal period averaged 6.3 days, with the extremes ranging from 4.7 to 9.2 days. The pupal case is reddish brown, rather slender, and subcylindrical in cross section. The faintly subshining surface is apparently bare, but under magnification shows scattered delicate pale short hairs on the body segments, which have a finely granular appearance. Measurements of 10 individuals averaged 8.5 and 2 mm. in length and width, respectively.

SEASONAL HISTORY.—The sorghum webworm hibernates in the larval stage on the food plant. With the advent of decreasing temperatures in October and November the worms gradually leave the heads of grain and move down on the sorghum stalks to protected situations behind the leaves which envelope the stalk. They show no pronounced gregarious tendency during hibernation and may be found distributed singly or in small groups along the entire length of the stalks. On warm days during the winter the larvae exhibit some activity and frequently crawl from place to place within the hibernating quarters; also, they continue to molt at irregular intervals during the cold season. Except mature larvae, all other stages of the insect succumb during the dormant period. Although long-cycle or overwintering larvae were noted in the laboratory during September, the bulk of the hibernating brood in the field does not generally seek shelter before October.

The overwintering worms begin to pupate when daily mean temperatures average 58 or 60° F. Normally these effective temperatures are attained in March. During the spring 1933 to 1936, inclusive, the emergence period of the moths averaged 10 weeks in duration; the extreme dates ranging from March 26 to June 13. In 1933 the peak of emergence occurred during the latter half of April, but during the three following years the moths did not emerge in maximum numbers until near the middle of May. Based on averages of the four seasons indicated above, about 43 per cent of the moths emerged prior to May 1, and slightly more than 97 per cent prior to June 1.

NUMBER AND SEQUENCE OF GENERATIONS.—During 1934, six generations of the insect were reared in the laboratory from April 21 to September 25. First-generation adults, which are here considered the progeny of the overwintering brood, began to appear on May 22 and continued emerging up to June 10. The duration of the life cycle ranged from 20 to 31 days. Fifty moths of the second generation emerged from June 14 to July 1 and required 19 to 25 days to complete their development. The first moths of the third, fourth and fifth generations emerged

on July 4, August 4 and August 28, respectively. Individuals of these generations attained maturity in 18 to 21 days. Temperatures during these developmental periods were considerably above normal and effected a heavy mortality among the caged larvae. Observations on the sixth generation included only 34 individuals, of which 11 hibernated as mature larvae; the others completed development and emerged as adults from September 25 to 29. These moths were paired in cages but failed to produce any eggs. However, when weather conditions remain favorable, reproduction continues in the field until late October, which allows sufficient time for the completion of a partial seventh generation in the latitude of College Station. It appears that the hibernating brood is not restricted to larvae of any definite generation; also, that the number of generations which may occur during a season is indeterminate. During seasons when rainfall is normal or above, six generations and a partial seventh are probably the common occurrence. The first three, which have developed for the most part by July 15, are usually too limited in numbers to produce extensive losses even in early planted crops. The fourth and subsequent generations produce the bulk of the injury, and crops with grain in the milk and dough stage during September or later suffer the greatest losses.

Prevention and control.—Among the natural factors affecting the normal activities of the sorghum webworm, climatic conditions are of greatest importance. The insect rarely proves troublesome during dry hot seasons, and apparently is unable to establish itself permanently in regions of the state where the annual rainfall averages less than 25 inches. Among the half-dozen species of parasites which were found to attack the larval and pupal stages of the sorghum webworm, only *Apanteles sorghiellae* Muesebeck seems of any appreciable economic importance. During October 1935, in a field under observation at College Station, about 38 per cent of *Celama sorghiella* larvae were parasitized by this species. Records from other fields ranged from less than 1 to 15 per cent parasitism in the samples taken.

The use of insecticides for control of the sorghum webworm is not practical, and the chief combative measures depend on crop management. Clean-up practices after harvest and timely planting are most important. Summarized briefly under these headings the control recommendations may be listed as follows:

Plow under stubbles and all other crop remnants during the fall or early winter and burn over all Johnson grass areas in the vicinity of grain sorghum fields to reduce the overwintering population of worms.

Infested crops harvested for forage should be fed before spring and the unconsumed stalks destroyed before pupation and emergence of the sorghum webworm begins.

Plant early to avoid extensive injury. Crops timed to mature by July 1 throughout central Texas are invariably damaged the least.

Use improved or pure strain seed and plant only one variety in a field. This insures the most uniform development of the crop and decreases the period over which it remains attractive as food for the insect.

Infested crops may be harvested promptly and fed as silage without any apparent injurious effect to live stock.—3-4-37.

Natural Dispersion of *Cochliomyia americana*

W. L. Barrett, Jr.,[1] *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Cochliomyia americana C. & P. does not survive the winter months in areas having low temperatures. Each summer, however, areas far beyond the northern limit of the winter survival area of the species become infested.

Bishopp & Laake (1921) have shown that *Musca domestica* L., *Phormia regina* Meig., *Ophyra leucostoma* Wied., *Cochliomyia macellaria* F. and several other species of flies are capable of flying considerable distances from a point of liberation. *Cochliomyia macellaria* was shown to have traveled 10 miles in approximately 48 hours. The greatest distance attained by that species was 15.1 miles. Parish (1937) has determined that adult *C. americana* are capable of traveling a distance of at least 9 miles in three days.

There are a number of ways by which *Cochliomyia americana* might be disseminated. As shown by Dove & Bishopp (1936) and by Dove (1936), this species is frequently moved long distances by the shipping of infested livestock.

A study of the natural seasonal spread of the primary screwworm fly is of special interest and importance in relation to the control of screwworms. This paper presents the results of observations made during the spring and summer of 1936 which indicate the natural rate of dispersion into areas in which it had been killed out by natural factors.

Method of investigation.—In this study the approximate rate of natural dispersion for the year 1936 was determined by placing a series of traps over an uninfested area approximately 50 miles wide and in the direction of migration some distance away from the zone of infestation. Then by thoroughly scouting the area for screwworm infestations in animals and by frequently examining the trap collections for specimens of *Cochliomyia americana*, the date of the first appearance of screwworms or screwworm flies in the area could be determined with a fair degree of accuracy. Many traps were set during the course of the work, but only those are recorded in which *C. americana* was captured. In some instances traps were set outside of the line of dispersion and were not in localities where flies were abundant.

In the beginning of the dispersion study, and until August 2, most of the work was done in a northerly direction from Uvalde, Tex. Later, scouting was shifted toward the northeast and east. Scouting toward the north was done along two main routes. One route was along highways U. S. 281 and U. S. 81, two roads on which traffic is relatively heavy between the north and south. The other route was one directly north of Uvalde, Tex., along which most of the traffic moved east and west. In all instances the survey was extended farther north as soon as the primary screwworm was found in any given locality.

[1] The writer is indebted to D. C. Parman, who planned and directed this work. Thanks are due A. W. Lindquist for helpful suggestions.

To determine whether invasion of uninfested areas took place by natural means rather than through the importation of infested animals, observations were made of animals in transit, and handlers at shipping pens and feeding stations along railroads were questioned from time to time. Inquiries were also made of stockmen regarding the animals they had shipped or imported. Examinations of automobiles and other vehicles were made to determine the possibilities of screwworm flies being dispersed by this means.

Results.—During the winter of 1935–36 proof was obtained by various workers of the Division of Insects Affecting Man and Animals, of the Bureau of Entomology and Plant Quarantine, that *Cochliomyia americana* overwintered in the vicinity of Uvalde, Tex. On March 5, 1936, A. W. Lindquist took specimens of larvae at Uvalde. This was the first record of the year of spring activity of the fly in that region. Field scouting was begun by C. C. Deonier of this Bureau in March, to determine the northern limit of overwintering. Deonier's work indicated that the northernmost overwintering boundary line of the insect was below the Balcones escarpment of the Edwards plateau and extended along the line of the Southern Pacific railroad between Devils river and San Antonio, Tex.[2]

Observations of the writer indicate that adult primary screwworm flies are rarely, if ever, disseminated by means of automobiles and trucks. No positive data were obtained that indicated that the shipment of infested livestock was a factor involved in the spread of the pest in the area surveyed, probably for the reason that in this area no direct main-line north-and-south highways are present. This does not minimize the known facts that infestations have been or may be established by shipment of infested animals.

Table 1.—Records of specimens of *Cochliomyia americana* taken during the 1936 dispersion study.

Place	Date	Collection
Uvalde, Tex.	March 5	Larvae
Johnson City, Tex.	May 8	Adults
Round Mountain, Tex.	May 8	Adults and larvae
Menard, Tex.*	May 9	Larvae
Lake Victor, Tex.	May 19	Larvae
Adamsville, Tex.	May 19	Adult
Austin, Tex.	May 21	Adult
Georgetown, Tex.	May 21	Adult
Coleman, Tex.	May 29	Larvae
Winters, Tex.	May 29	Larvae
Belton, Tex.	June 9	Larvae
Waco, Tex.	June 9	Adult
Brownwood, Tex.	June 12	Adult
Ballinger, Tex.	June 12	Adults
Bradshaw, Tex.	June 12	Adult
Cisco, Tex.	June 12	Larvae
Baird, Tex.	June 12	Larvae
Throckmorton, Tex.	June 15	Larvae
Wichita Falls, Tex.	June 22	Larvae
Davidson, Okla.	July 7	Adult
Meers, Okla.	July 8	Larvae
Arnett, Okla.	July 16	Larvae
Fargo, Okla.	July 31	Larvae
Buffalo, Okla.	August 2	Larvae
Ft. Cobb, Okla.	August 5	Adults
Independence, Tex.	August 12	Larvae
Anderson, Tex.	August 12	Larvae
Hearne, Tex.	August 13	Larvae
Mexia, Tex.	August 14	Larvae
Fairfield, Tex.	August 14	Larvae
Palestine, Tex.	August 15	Larvae
Trinity, Tex.	August 18	Larvae
Hooks, Tex.	September 2	Larvae

* Reported by H. E. Parish.

Table 1 presents the positive data taken during the survey. It is believed that determination of the presence of the species in each of these localities was made soon after the advent of the insect except in parts of eastern Texas, where work was begun late in the summer.

Between March 5 and August 1 the species spread from Uvalde to a point southeast of Buffalo, Okla., a distance of about 525 miles. The fly was not found at Menard, Tex., about 100 miles north of Uvalde, until May 9. Cool weather preceding that time was probably re-

[2] Mr. Deonier continued to work on the problem until May 21; the writer began scouting with him on May 8.

sponsible for the slowness of the movement of the fly until then. The average rate of the northward dispersion per week during the 12-week period preceding August 1 was 35.4 miles. During part of the time the dispersion rate appeared to exceed the average by as much as 15 miles a week.

The dispersion in northern Texas occurred from areas of low infestations, and the spread in Oklahoma was from localities in which the fly population was very low. The rate of dispersion was more rapid directly to the north of Uvalde through the sheep and goat breeding area than east of this area along the heavily traveled highways U. S. 281 and U. S. 81.

Following the finding of larvae near Buffalo, Okla., the southwestern part of Kansas was scouted along the Cimmaron river, to the south of Sitka. A number of ranches were visited there, but no reports of screwworm cases during 1936 were received and the ranchmen agreed that 1935 was the only year that screwworms had occurred in this section. From this evidence it appeared that the migration had reached its approximate northern limit for the season or was at a standstill, and further study on the northward dispersion was discontinued on August 3. The dispersion toward the east was marked by an abrupt stop at Palestine and Trinity, Tex.

Cochliomyia americana had reached Johnson City, Tex., on May 8, and although the records on the northeasterly and easterly migration were obtained comparatively late in the season, it is indicated that in going northeast to Texarkana it spread about 325 miles in 16 weeks. The average distance traversed per week in a northeasterly direction was therefore 20.3 miles per week, which was much slower than the dispersion rate toward the north.

Summary and conclusions.—Without discounting the well-known fact that screwworms are frequently carried into uninfested territory in shipments of infested animals, the appearance of adults of *Cochliomyia americana* and the occurrence of screwworm cases on successive dates in the previously uninfested areas progressively farther away from the overwintering zone without any close relation to livestock shipment indicate that the movement of the pest toward the north in the area under observation was by natural migration.

From March 5 to August 1, 1936, this species evidently migrated from Uvalde on the northern boundary line of the overwintering area in southern Texas to Buffalo, Okla., near the boundary of Kansas.

The average weekly rate of dispersion (after the advent of continuously warm weather) was about 35.4 miles toward the north and about 20.3 miles toward the northeast. The rate of spread toward the east was much slower. At times, however, the rate of weekly dispersion to the north apparently exceeded the average by 15 miles.

The rate at which the fly dispersed shows that under favorable conditions areas about 1500 miles from the northern edge of the overwintering zone may become infested as a result of the seasonal spread of the insect.

The fly appears to disperse readily from areas in which the population of the species is low.

Adult flies are not ordinarily carried by moving vehicles.—8-16-37.

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Insecticides to Control Blowfly Larvae in Wounds

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Bishopp, Cook, Parman, & Laake (1923) stated that 100 per cent benzol had been found more satisfactory than chloroform for treating wounds infested with screwworm larvae. Parman (1925) presented data which showed that benzol was the best larvicide for screwworm control. Bishopp, Laake & Parman (1926) stated, "If there is a comparatively small hole in the skin at the site of infestation it is best to pour a small quantity of the benzol into the hole and plug it with cotton. Benzol does not mix readily with blood or serum, hence it is necessary to remove the free exudates with cotton before applying the benzol." Dove (1935) recommended two applications of benzol followed by the insertion of a cotton plug in the opening of the wound. Bruce & Sheely (1936) recommended cleaning the wound, applying benzol, cleaning the wound again, applying more benzol, and then plugging the wound with dry cotton.

The object of the present study at Valdosta, Ga., is to develop a larvicide that can be used more rapidly than benzol and with less manipulation of the wound.

Procedure in the present study.—Goats and sheep that had one or, more often, two wounds infested with nearly mature larvae of *Cochliomyia americana* C. & P. were treated after a few larvae had dropped from the wound or when the larvae were about ready to start dropping. In this way all the treatments were applied to large larvae in their normal habitat in wounds. None of the fluids, such as pus, serum or blood, were removed from the wound before the larvicide was applied. The insecticide was simply poured into the wound from a graduated cylinder until the wound, which was either on the rump or shoulder, was full. An average of 5.4 cc. of insecticide was applied to each wound, the maximum being 15 and the minimum 2 cc. An average of 7.4 cc. was applied to the wounds treated with benzol. The animal being treated was held until the larvicide had stood in the wounds for an average of 35 seconds. At the end of this period the animal was immediately placed in a collecting cage where any excess fluid, often including part of the larvicide, drained out of the wound.

These collecting cages[1] were made of lumber and were just large enough to hold comfortably a sheep or goat of medium size. A hinged top restrained the animal from jumping out. The floor of the cage was slatted and the sides and ends were solid. Below the floor was a screen funnel that opened into a small tub, the bottom of which was covered with about 1 inch of dry sand. Any larvae that dropped from the wounds after treatment were trapped in the sand. One hour after treatment, and at daily intervals thereafter, the sand in the tub was changed. By this

Table 1.—Larvicides applied to wounds on goats and sheep infested with screw-worms (larvae of *Cochliomyia americana*), Valdosta, Ga., 1936.

Larvicide		Wounds Plugged with Cotton	No. Wounds Treated	No. Flies Emerged per Wound	Estimated* Percentage of Control
Material	Proportion *per cent*				
Soluble pine oil No. 1†	98	No	12	.08	99.8
Methyl thiocyanate	2				
Soluble pine oil No. 2‡	98	No	33	.12	99.8
95% nicotine	2				
Benzol§	100	Yes	23	.3	99.4
Benzol	100	No	16	4.93	90.7
Soluble pine oil No. 2	100	No	12	7.67	85.6
Soluble pine oil No. 1	100	No	4	21.5	59.7
Untreated		No	23	53.29	0.

* As the number of larvae in the treated wounds could not be determined accurately without greatly disturbing the position of the larvae in the wound and probably the effect of the larvicide on them, the exact number of larvae in the treated wounds was not determined. However, all the treated wounds and the untreated wounds contained approximately equal numbers of larvae and all treatments were applied at random. "Estimated" is therefore used to describe the percentage of control because this percentage is not based on the actual number of larvae treated but on the average number of larvae in the untreated wounds.

† Soluble pine oil No. 1 consisted of 75 per cent destructively distilled pine oil and 25 per cent sulfonated castor oil neutralized with ammonium hydroxide. Ninety per cent of this pine oil distilled from 199 to 216° C at atmospheric pressure.

‡ Soluble pine oil No. 2 consisted of 75 per cent of a different destructively distilled pine oil and 25 per cent sulfonated castor oil neutralized with ammonium hydroxide. Ninety per cent of this pine oil distilled from 115 to 210° C at atmospheric pressure. Also this pine oil had been oxidized and the acid formed neutralized.

§ The benzol used in these tests was a commercial grade and contained 90 per cent or more of benzene.

means conditions approximating those in nature were obtained. The animals were free to move to a considerable extent in the cages and could lick or gnaw their wounds. At the same time any larvae that left the wound soon reached clean sand in which they could crawl or burrow, thus possibly removing some of the insecticide. The larvae that were removed from the sand were placed in glass jars about one-fourth full of slightly moistened sand and covered with screen tops. These jars were stored under suitable conditions of temperatures and moisture until all the flies had emerged or the larvae or pupae had died. The flies in these jars were counted and the results recorded.

Usually on the fourth or fifth day after treatment, and sometimes later, and at least one day after the last living larvae had been observed in the wound or caught in the sand, the animals were taken out of the collecting cages, and all the dead larvae in the wounds were removed and counted.

[1] This type of cage was designed by Dr. Roy Melvin and modified by E. F. Knipling and the author.

Tests and results.—In table 1 are summarized the results obtained with six treatments that are of special interest, selected from approximately 175 larvicides applied to screwworm-infested wounds in goats and sheep.

The data in table 1 show that under the conditions prevailing when these tests were run (1) soluble pine oil No. 1 98 per cent, methyl thiocyanate 2 per cent; (2) soluble pine oil No. 2 98 per cent, 95 per cent nicotine 2 per cent; and (3) benzol with a cotton plug in the wound, were effective larvicides. The first material allowed one fly to emerge from larvae from one wound, the second material allowed one fly to emerge from larvae from one wound and three flies from larvae from another wound, and benzol with a cotton plug allowed seven flies to emerge from larvae from one wound. In a few tests 40 per cent sodium resinate or 25 per cent sulfonated castor oil neutralized with sodium hydroxide was used to emulsify the same pine oil as was used in soluble pine oil No. 1 in table 1. When 2 to 5 per cent of methyl thiocyanate was incorporated into these soluble pine oils, less complete control of the larvae in wounds was obtained than with the methyl thiocyanate treatment as given in table 1.

When the animals were released from the collecting cages after all the living larvae had dropped from their wounds, the soluble pine oil No. 1–methyl thiocyanate treatment left an average of 9.2 dead larvae per wound, the soluble pine oil No. 2–nicotine treatment an average of 26.4 dead larvae per wound, and the benzol-cotton plug treatment 39.5 dead larvae per wound.

None of the treatments given in table 1 appeared to be injurious to the wounds or to the general condition of the goats or sheep treated.

Discussion.—Most of the wounds treated in these tests had a rather small hole through the skin and a small open cavity in the wound. Since the wounds were treated as soon as a few larvae had dropped from them the larvae were tightly packed in the wounds in most instances when the larvicide was applied. Preliminary tests had shown that larvae of this age in this particular type of wound were the most difficult to kill. When a cotton plug was used in such a wound it usually stayed in the wound until removed by hand. This condition almost sealed the larvae in the wound with the larvicide, which, of course, provided almost ideal conditions for the benzol to act. In cases with large open wounds, where it is often impossible to keep a plug in the wound after the animal is released, somewhat different results might have been obtained. If the fluids had been removed from the wounds before the larvicides were applied, however, the control with all the materials tested would probably have been improved.

The mixture of soluble pine oil No. 2 and nicotine killed the larvae quickly. The larvae became motionless in a few seconds, and very few if any of them crawled out of the wound before they died. In contrast with this the soluble pine oil No. 1–methyl thiocyanate mixture stimulated many of the larger larvae to crawl out of the wound before they died. As has been stated, only about one-third as many dead larvae were found in the wounds treated with the soluble pine oil No. 1–methyl thiocyanate mixture as in wounds treated with soluble pine oil No. 2–

nicotine mixture. Whether this reduction of the number of dead larvae remaining in the wound after treatment would materially reduce the period required for the wound to heal has not been determined, but it seems possible that it might do so.

Fewer larvae occurred in the wounds used in these tests than are usually found in wounds in nature. However, as these wounds and larvae were of uniform size and age, a rather accurate comparison of the relative efficacy of the larvicides was obtained.

Summary.—Two soluble pine oils when combined with 95 per cent nicotine and methyl thiocyanate, respectively, and benzol with a cotton plug in the wound were effective larvicides for the treatment of wounds on goats and sheep infested with screwworms (larvae of *Cochliomyia americana*).—3-20-37.

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PACIFIC SLOPE BRANCH

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Factors Concerned in the Deposit of Sprays

III. Effects of Wetting and Emulsifying Powers of Spreaders

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Regulation of the amounts of the oil which will be deposited by spray emulsions upon a surface forms one of the more important problems in the use of oil sprays. This is due to the fact that both the insecticidal efficiency of the spray emulsions and their harmfulness to plants depend upon the quantity of oil which they can deposit. The narrower the range between these two properties, the greater is the need for exact regulation of the amount of oil which is left upon the sprayed surface. To accomplish this end, however, a thorough knowledge of the principles which govern

[1] Contribution from the laboratory of insect physiology and toxicology, Division of Entomology and Parasitology.

the deposit of oil is required. It is with this purpose in mind that an investigation of the problem was started a few years ago in this laboratory.

In the general field of oil spray investigations deposit has attracted the attention of a number of entomologists and several articles have been published on various phases of the work. de Ong & Knight (1925) approached the problem from the viewpoint that factors which control the oil deposit will depend upon the stability of the emulsion and that the weaker this is the higher the deposit will be. They suggested therefore that the emulsion should approach as nearly as possible the mechanical mixture type. de Ong, Knight & Chamberlin (1927) continued these studies and advised the use of weak emulsifiers, so as to obtain quick-breaking emulsions which will give high oil deposits. Griffin, Richardson & Burdette (1927) pointed to the relationship between the size of the oil globules of the spray and the deposit. They claimed that the larger the size of the globules the greater will be the quantity of oil which will be retained upon the surface. This was believed to be influenced by the electrostatic charge of the oil globules which tends to repel them from the sprayed plant. The smaller the oil globules the more intense the charge per volume and therefore the less oil deposited. Smith (1932) considered the influence of the wetting power of the spray upon the amount of the oil deposit. He asserted that higher deposits will be obtained with sprays which wet poorly, as compared with those which possess a good wetting power, because of the formation in the latter case of a spray film which prevents the succeeding spray from depositing its oil content. Smith (1932), Borden (1934) and Borden & Hensill (1934) made comparative studies of the amounts of oil which will be deposited by various commercial oil emulsions then in current use. They reported great variation in oil deposits among the various emulsions and pointed to the necessity of acquiring an exact knowledge on this point if satisfactory results are to be obtained.

Hensill & Hoskins (1935) made a quantitative study of the amounts of oil which will be deposited with certain protein and soap spreaders by means of the 'tank mix' method. Much detailed data on oil deposits were obtained, calling for further study and interpretation. It is this study which the present work undertakes. This paper forms a direct continuation of their investigations and seeks to answer some of the problems that were presented. For definitions of various terms reference should be made to the earlier paper.

Materials and methods.—The spreaders that were selected for this study were of the water-soluble type, *i.e.*, materials which are soluble in the water but not in the oil phase of the emulsion. Two different kinds of these spreaders were used: the wetting agents, so-called because of their good wetting but poor emulsifying properties; and the emulsifiers, which possess these properties in the opposite ratio. This choice was made purposely so as to facilitate a study of the influence of these important properties of the spreaders upon the oil deposit. The proteins, *Mapco* dried blood albumin and hemoglobin, were selected to represent the wetting agents, and the soap sodium oleate as the emulsifier. The albumin was a commercial product containing many other constituents of beef blood besides the albumin. The hemoglobin was prepared in the

laboratory from beef blood with every effort to obtain a pure and unchanged product, and the soap was commercial U. S. P. material. The spreaders were used at concentrations varying from zero up to .0225 per cent by weight (852 mg. per gallon or 3 ounces per 100 gallons) which covers the ordinary range used in practical spraying. The oil used was a white neutral tank-mix stock of 80 seconds Saybolt viscosity and 92 per cent unsulfonatable residue. Fresh lots were obtained from the refinery at frequent intervals since spray oils change their properties with age.

The spraying apparatus and procedure were much the same as those described before (Hensill & Hoskins 1935) except that a gear pump was

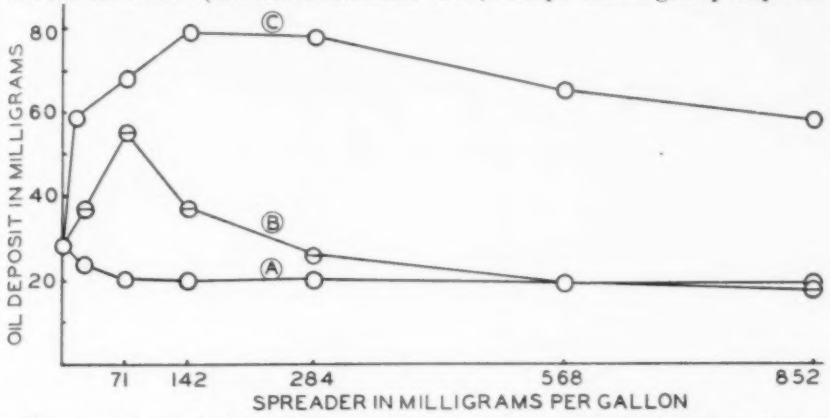

Fig. 1.—Deposits of oil obtained with the three spreaders. *A*, sodium oleate; *B*, blood albumin; *C*, hemoglobin.

used and a much thinner and more uniform coating of beeswax was obtained upon the sides of the 4-ounce oil sample bottles by dipping them in a saturated solution of the wax in carbon tetrachloride. The solvent was removed by allowing the treated bottles to stand in the laboratory for 24 hours before use. Precautions regarding uniformity of emulsions, character of spray discharge, measurement of volume sprayed, evaporation of excess water and weighing of deposit were taken as before. For certain photographs of spray in action to be described later, use was made of the device for taking pictures with an exposure of .001 second, Craig (1936).

Oil deposits.—The amounts of oil deposited per bottle (153 sq. cm. lateral area) by 2 per cent oil emulsions containing several concentrations of each spreader are shown in fig. 1. It is obvious that there is a fundamental difference in the nature of the curves for the proteins and that for the soap. The former pass through a maximum at some intermediate concentration of spreader, whereas the latter is always lower than the initial point which represents a mechanical mixture of oil and water alone. An explanation of the variations in the amount of oil deposited from the different emulsions in terms of properties conferred upon them by the spreaders is the object of the further work to be presented in this paper.

It seemed impossible to interpret the results in terms of tensions, angle

of contact and other similar functions such as have engaged the attention of numerous earlier workers. (For references and discussion see Hensill & Hoskins 1935.) The chief reason for the difficulty lies in the fact that these properties have been measured under static conditions whereas the application of a spray is a dynamic process during which there is rapid movement and surfaces and interfaces are constantly being changed. It appeared probable that pertinent information could be gained by a study of the actual process of spraying. To do this the apparatus for high-speed photography was used to take a great many pictures of the various emulsions as they were being sprayed upon the wax surface. In fig. 2 are shown

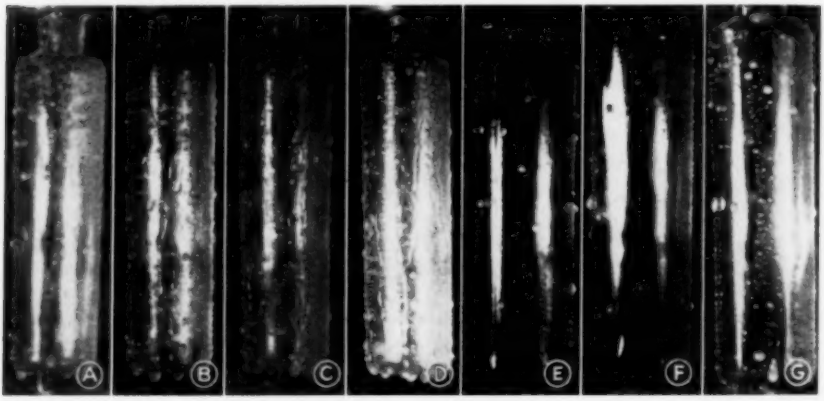

Fig. 2.—Behavior of oil emulsions during application to a wax surface. *A*, no spreader; *B*, .00093 per cent (35 mg./gal.) hemoglobin; *C*, .00375 per cent (142 mg./gal.) hemoglobin; *D*, .015 per cent (568 mg./gal.) hemoglobin; *E*, .00093 per cent sodium oleate; *F*, .00375 per cent sodium oleate; *G*, .015 per cent sodium oleate.

the conditions which prevail when sprays containing different concentrations of hemoglobin or of sodium oleate are applied. The photographs were made after 10 seconds of spraying, which is about two-thirds of the time required to apply the standard amount for 20 cc. run-off. The conditions with blood albumin are similar in general to those with hemoglobin.

Wetting.—Examination of these photographs shows that the degree of wetting that prevails during the application of these emulsions to a beeswax surface may be divided into three fairly distinct types. The first, illustrated by the mechanical mixture and by all of the soap emulsions, is characterized by more or less hemispherical drops which make a high angle of contact with the solid and roll down the wax surface with little or no tendency to elongate or form long tails. The area of contact between the emulsion and the solid is relatively small and there is a correspondingly small opportunity for the oil droplets to come in contact with the solid surface. Hence, low deposit is to be expected. The second type of wetting is illustrated by the low and intermediate concentrations of the two proteins. The drops are much flatter, cover a larger area on the solid and become much elongated as they roll down the surface. There is abundant opportunity for the oil droplets to make contact with the solid,

especially since, as observation shows, they tend to concentrate in the long tails behind the moving drops of emulsion. Accordingly deposit may be expected to increase as this condition becomes more marked. The third type of wetting is shown by the higher concentrations of the proteins. In this the elongated drops tend to merge into continuous streams and sheets which move over the surface more slowly so that a considerable portion of the solid is covered by them during most of the time the spray is applied. Such continuous areas of liquid largely prevent the oncoming spray from gaining access to the solid and for this mechanical

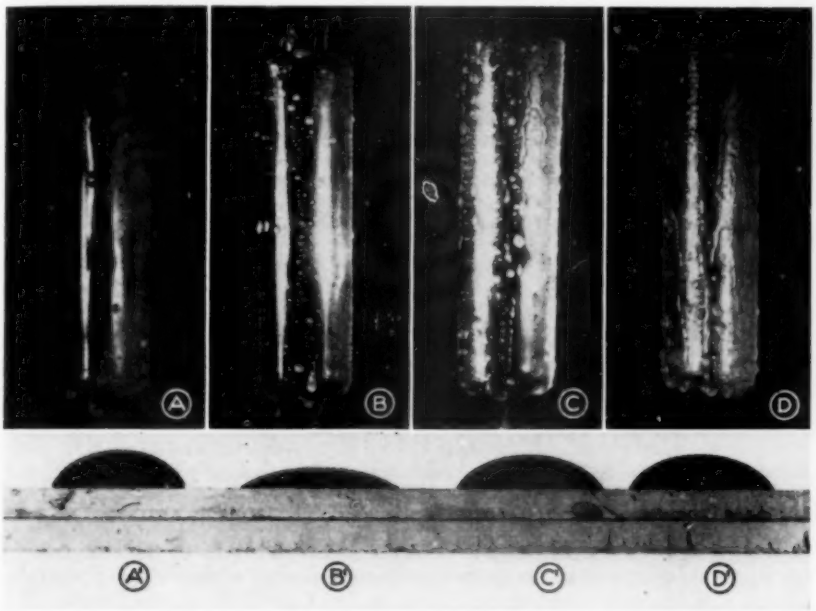

Fig. 3.—Dynamic and static behavior of oil emulsions upon a beeswax surface. *A*, *A'*, no spreader; *B*, *B'*, .0225 per cent (852 mg./gal.) sodium oleate; *C*, *C'*, .0225 per cent blood albumin; *D*, *D'*, .0225 per cent hemoglobin.

reason a decrease in deposit is to be expected with high concentrations of the proteins.

These variations in the types of wetting shown by various emulsions as they are forcibly sprayed upon a solid are not indicated to the slightest extent by the ordinary methods of studying area of wetting or angle of contact under static conditions. To illustrate the misleading conclusions that may be drawn from such measurement there is shown in fig. 3 the behavior while a mechanical mixture and emulsions containing the highest concentrations of sodium oleate, blood albumin and hemoglobin are being sprayed and also the results when drops of these same emulsions are placed upon a similar wax surface. In the latter case the initial changes in shape and area are almost entirely complete within two minutes, so that the photograph of the drops was taken after that in-

terval. It will be noted that there is comparatively little difference in the behavior of the mechanical mixture, the albumin emulsion and the hemoglobin emulsion, but that the soap emulsion has spread to a much greater extent. From such experiments it would be concluded that soaps give much better wetting than proteins on a waxy surface, as was in fact stated by Moore (1921). There is practically no correlation between the dynamic and static conditions and results obtained in the latter way give no reliable information as to the behavior of a spray in actual use. This conclusion, of course, does not apply to special methods of spraying, such as the work of Evans & Martin (1935).

The experimental results for deposit of oil from the various emulsions cannot be explained entirely in terms of differences in wetting during application, *e.g.*, the sudden decrease in deposit as small amounts of sodium

Table 1.—Stability of emulsions containing equal volumes of oil and water and varying concentrations of spreaders, expressed in time in minutes and seconds for 50 per cent of the oil to separate from the emulsions.

Spreader Concentration Mg. per Gal.	Emulsions Containing Hemoglobin	Blood Albumin	Sodium Oleate
0	45s	45s	45s
24	5±s	1m	10m
71	1m	1m 30s	15m
142	3m	4m 30s	22m 30s
284	6m 30s	9m 30s	20m
568	10m	21m	24m
852	17m	33m	36m

oleate are added does not correspond to the very slight increase in wetting power.

A property of emulsions whose importance has been emphasized often in work with sprays is their stability (Moore 1921; deOng, Knight & Chamberlin 1927; Smith 1932). Actual contact of oil with a solid surface can occur only in so far as the layer of emulsifying agent in the interface between oil droplet and water is ruptured so that the oil can escape. For use in studies on deposit the stability of emulsions should be studied under dynamic conditions but a dependable method for doing this is lacking, and so ordinarily recourse is had to determination of the time for a certain percentage of the total oil present to separate and rise to form a separate layer. This method was used with the several emulsions whose oil-depositing powers were shown in fig. 1. To reduce the error in reading the volume of liberated oil, concentrated emulsions were prepared from equal volumes of oil and water with the various spreaders at the same concentrations per total volume as were used in the deposit study. The materials were put together in narrow beakers, agitated in a uniform manner for two minutes with an electric mixer and then allowed to stand. The time required for one-half of the oil to separate was estimated from the depth of the more or less clear layer of oil which collected at the top. From emulsions containing so much oil there is little tendency for cream to rise and the chief error involved is the slight delay with which oil that separates within the emulsion rises to the top.

The results of this method, table 1, were closely reproducible and while

it is not claimed that they represent with exactness the stabilities of the more dilute emulsions that were used in the work on deposit, the difference between the protein and the soap emulsions is very pronounced. The stability conferred upon the emulsion by very small amounts of sodium oleate is in entire agreement with the abrupt decrease in deposit which is caused by this substance. While neither of the proteins at moderate concentrations gives stable emulsions the relatively greater stability with blood albumin is in agreement with the fact that it gives lower deposits than hemoglobin. Throughout the range of high concentrations both form fairly stable emulsions.

Effects of wetting and emulsifying powers upon deposit.—The interpretation of the curves for oil deposited from emulsions containing the three spreaders may be made in terms of the combined effects of dynamic wetting power and stability of the emulsions. The foregoing discussion has indicated that an increase in wetting power, particularly when it results in moderate elongation of rolling drops, favors increase in deposit of oil. This influence continues until an appreciable portion of the surface is continually covered by streams and sheets of liquid so that the latter portion of the applied spray is mechanically prevented from depositing any large part of the oil it contains. Hence excessive wetting power affects deposit adversely. Emulsifying power always acts to decrease deposit. Applying these considerations to the deposits obtained with protein spreaders, it follows that with low concentrations the marked increase in wetting power and the very slight increase in emulsifying power should lead to a sharp increase in oil deposit over that obtained with a mechanical mixture. Upon further increase in spreader both wetting and emulsifying power become so pronounced that the deposit passes through a maximum and thereafter decreases. In the case of the soap spreader the wetting power is never great enough to increase the deposit significantly, whereas the emulsions become so stable even with very small amounts of spreader that an immediate decrease in deposit occurs.

It is thus possible to account qualitatively for the two kinds of deposit curves. Specific effects undoubtedly are concerned also, *e.g.*, the sharp drop following the maximum point with blood albumin contrasts with the comparatively small decrease in the case of hemoglobin, a difference in behavior that cannot be accounted for satisfactorily as yet. Though both materials are proteins, they are very different chemically, for the blood albumin is a commercial product which contains almost everything that occurs in blood serum and it was subjected to a high temperature during drying. The hemoglobin was never heated and was kept in solution at a low temperature continuously so that changes in molecular structure were minimized.

Although this investigation has been limited to three spreaders it is probable that results similar to those for hemoglobin and blood albumin will be obtained with all typical wetting agents and that the behavior of sodium oleate is characteristic of all typical emulsifiers.

Summary.—The deposit of oil obtained upon a standard beeswax surface from a fixed volume of an emulsion containing the protein spreaders hemoglobin or blood albumin, increases as small amounts of the spreaders are added, reaches a maximum at a concentration characteristic for

each and decreases as larger amounts are used. On the other hand, all emulsions containing the soap sodium oleate, deposit less oil than the mechanical mixture of oil and water. These different behaviors are explained on the basis that deposit is favored by an increase in wetting power until the latter is so great that much of the surface is continually covered during the application. Wetting power must be studied by dynamic methods for static measurements are misleading. Emulsifying power always decreases deposit. Application of these conceptions explains the two types of deposit curves. It is believed that a maximum will be obtained at some intermediate concentration of all typical wetting agents and that all typical emulsifiers will decrease deposit at all concentrations.—9-10-37.

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Control of the Garden Centipede in California

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Winter flooding is the best method for control of the garden centipede, *Scutigerella immaculata* (Newp.) in asparagus fields. Wymore (1931) has published the most recent paper dealing with this method. Since 1931 the writer has been interested in this problem, and has observed conditions in the delta of the Sacramento and San Joaquin rivers where flooding as recommended by Wymore was not practical. For successful winter flooding the land should be covered with a foot or more of water for a period of about two weeks or longer. There are areas in the delta where such a procedure is not possible, either because of excessive seepage or because of unevenness of the land. Where asparagus is being grown no substitute measure has been found, but where the land is devoted to field crops, flooding during the warmer part of the season has given much

promise. Summer flooding was first suggested by the writer in 1935. During May of 1934 a heavily infested field was flooded for a period of about six days. The depth of water ranged from an inch or two to about six inches. It was observed that many of the garden centipedes were killed during the first day that the land was covered with water, and at the end of the period of flooding 88 per cent of the pests were killed. This gave evidence that a depth of water of a foot or more was not necessary to bring about a heavy mortality during warm weather. In fact it appeared that water only a few inches deep was desirable since it warmed up faster than water of greater depth. It was also observed that the garden centipedes move from the deeper soil into the cultivated surface soil when a field is flooded, where they are more easily killed by flooding. Some of these reactions are more fully discussed in an article, "The biology of the garden centipede, *Scutigerella immaculata*, in California," which is to appear in *Hilgardia*, California Agricultural Experiment Station publication.

The control obtained was sufficient to insure a good crop for that season, but during the summer there was a marked build-up in the population so that sugar beets planted the following spring were severely injured. Numerous population counts were made during the growth of the sugar beets and by midsummer the number of garden centipedes present per acre based upon those actually recovered in the samples taken was approximately eight million. For each survey 12 samples were taken with a cylindrical tube 4 inches in diameter and having a half-inch slit running nearly its entire length to facilitate removing the soil. Samples were usually taken to the depth of 18 inches although when the surface soil was extremely dry sampling was extended to about the 24-inch level. A water-flotation method was used in separating the garden centipedes from the soil. Information on the distribution of the garden centipede, along with a second symphylan, *Symphlella* sp., which apparently is not injurious to growing vegetation, is being prepared for publication elsewhere. Because the surface area of the sampler is approximately one five-hundred thousandth of an acre, the estimated number of garden centipedes per acre based on the actual recovery can be determined by dividing the average number collected per sample by two and multiplying by one million.

During the first part of October 1935 the field was flooded for a second time. No garden centipedes were found in a population study conducted in November. In January 1936 the field was planted to sugar beets and a perfect germination stand resulted, the first that had been obtained on this particular piece of land for some years. In a survey made during that month two garden centipedes were recovered, but population counts made in March and April produced no garden centipedes, and a single specimen was recovered in the 12 samples taken in May. The field was again surveyed in August and this time 12 individuals were recovered, or an average of one per sample. Most of the individuals collected were small, but the population had built up sufficiently so that the pest could be rather easily found. The crop was harvested about 10 days previous to the August survey, and because of the early removal of the beets it was decided to flood the field again, although the garden centipede population

had not built up to a point where it would be destructive the following year. This was obvious since following the August survey there was not time for the pest to increase sufficiently to do damage. The field was flooded during the first part of September, and no garden centipedes were found in a survey conducted the following December. A summary of the data obtained for 1935 and 1936 is given in table 1.

Table 1.—Population trends of the garden centipede, *Scutigerella immaculata* (Newp.) in a field devoted to sugar beet culture.

Comments	Date Surveyed	No. Individuals Collected per Sample*												Total No. Collected	Av. No. Collected per Sample
		1	2	3	4	5	6	7	8	9	10	11	12		
Seedlings just showing above ground	2–14–35	5	1	4	2	23	14	3	3	21	1	1	13	91	7.58
Beet severely injured	3–12–35	15	6	6	2	26	3	38	4	58	5	4	2	169	14.08
Field replanted; seedlings not severely injured. Some natural factor reducing population	4–25–35	4	1	3		5	5	7	2	15	1	3	3	49	4.09
In places soil rather dry to depth of 18 inches. Eggs and young common	6–12–35	11	8	12	4	14	1	6	6	8	13	3	9	95	7.91
Surface soil dry. Water table 14 to 20 inches. Many young garden centipedes	7–16–35	12	1	12	1	40	8	26	8	26	27	25	23	209	17.4
Beets reaching maturity. Soil drying out to 12 inch level. Many young garden centipedes	8–23–35	29	9			25	43	9	9	20	30	18	14	206	17.21
Beets harvested. No samples taken of very dry surface soil. Sampling extended to 24 inch level	9–16–35	13	20	1	1	24	12	26	29	30	15	11	7	189	15.75
Field flooded during first part of October 1935	11–11–35														
Soil rather wet. Field to be planted to sugar beets in a few days	1–21–36	1							1					2	.16
Soil very wet below 6-inch level. Perfect germination stand	3– 5–36														
Surface soil becoming dry. Beets doing nicely	4–22–36														
Surface soil dry, wet at 18 inches. Beets making good growth	5–25–36						1							1	.083
Crop harvested 10 days previously. Many of the individuals collected small	8– 4–36					1	4	1	4	1		1		12	1.
Soil very moist. Field flooded during first part of September	12–10–36														

* During cropping period, odd numerals represent samples taken in row, even numerals represent samples taken in interspace.

It appears that flooding during the warmer part of the year can be successfully used in controlling the garden centipede. Flooding during early or late spring is not so desirable as later in the year since any surviving garden centipedes will not have an opportunity to build up the population after the late flooding before the crop is planted the following season. For best results flooding should be done during the hottest part of the summer. At this time to give good control the land needs to be flooded for only a very short period (several days to a week). Where land is known to be severely infested, the crop should be harvested at the earliest possible date and the land flooded immediately upon its removal.

If such a crop as peas is not followed by a second crop, for example beans, the land can be flooded at any time during the warmest part of the summer. Properly done, summer flooding should control the pest for at least two years, and the writer believes that if flooding is done under optimum conditions control should result for longer. The field in which the experiment under discussion was carried out apparently affords ideal conditions for the garden centipede. The symphylan has continued to be a serious pest in this field since it was first noted. In other fields in the same general region the garden centipede has only on occasions become destructive. In such fields less suited to the pest, summer flooding might be even more effective than in the field that was used for the present investigation.

Influence of crops.—Different crops call for different management which in turn apparently markedly influences the conditions under which the garden centipede must live. In the delta regions of the Sacramento and San Joaquin rivers, sugar beet culture appears to favor the pest, while onion culture probably has the reverse effect. It is possible that sugar beets form a better diet for the garden centipede than do onions, but the writer is inclined to believe that the difference in culture is even of more importance. In general when land is planted to sugar beets the population increases, but when planted to onions it decreases. Frequently when heavily infested beet land is planted to onions a satisfactory stand is not obtained. This might suggest that onions highly favor the pest, but the writer believes that probably a very large garden centipede population has built up while the ground was in beets, which accounts for the destruction of the onion stand. This theory is also supported by the fact that on infested land where beets follow onions a good germination stand of beets is frequently obtained.

The growing of onions calls for a great deal of cultivation and considerable water. The implements used tend to pack the surface soil. The onions are subirrigated by running water through "spud ditches" spaced at intervals throughout the field. In general the water table is maintained at a rather high level. The result is that soil above the water level is rather compact, and while the garden centipede maintains itself, the environmental conditions are not conducive to a high rate of reproduction and the build-up of large populations. Time has permitted the study of the population trends in only one field where a sugar beet crop was followed by onions. During the time the land was in onions there was a decrease in the population. This continued to the next spring after the field had been planted to sugar beets. The decline during the winter is natural because reproduction is almost at a standstill. However, with warmer weather there was a marked build-up in the population. The last survey was made on June 30. Many of the garden centipedes found then were very small, and all indications were that a later survey would show a

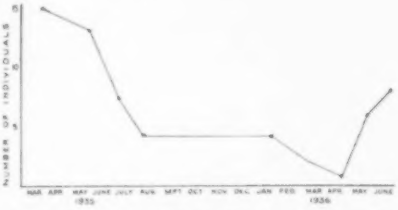

Fig. 1.—Population trend of the garden centipede during growth of an onion crop followed by a sugar beet crop.

further increase in numbers. The population trend during the growth of the onion and sugar beet crops is shown in fig. 1.

Calcium cyanamid treatment.—Calcium cyanamid has been reported as being effective in controlling the garden centipede. Experiments were performed in the field and greenhouse and, while no exact population studies were conducted, no evidence of any kill was obtained. In the field the material was used at the rate of 600, 900 and 1200 pounds to the acre. A single case was observed, however, in which it appeared that calcium cyanamid might have exerted a controlling influence, but the improved growth noted was probably due to correction of a nitrogen deficiency in the soil. Evidence indicates that calcium cyanamid has very little direct action upon the garden centipede, but may be very beneficial if applied to infested soil deficient in available nitrogen.

Carbon disulfide.—This material has been widely used against the garden centipede. For best control soil temperatures of 65° F or higher are desirable. The use of this chemical is limited due to its high cost. It is chiefly used in greenhouses where crops are grown that bring a high return. In the field carbon disulfide is used only under very special conditions. In 1936 an experiment was performed to determine whether garden centipedes in a levee surrounding a flooded field could be successfully killed during the winter. The soil was very moist to wet and the prevailing temperature at the 6-inch level ranged from about 48° to 52° F. Small sacks made of fine bolting cloth were partly filled with soil that had a firm structure. Ten garden centipedes were added to each sack and the sacks sealed by folding the open end and securing it with a clip.[1] Holes 18 inches deep were then dug in the levee. The first hole was placed on the crest and three others were placed at 18-inch intervals down the side of the levee away from the water. A second series paralleling the first was placed at a distance of 36 inches. One sack was placed in the bottom of each hole, which was then filled with soil and carefully packed until the depth was reduced to 14 inches. Another sack was placed in each of the holes and the performance repeated until there were sacks at the 10, 6 and 3-inch levels. The depth of each sack was denoted by a string which was attached to the clip and to a stake above the ground marking the depth. The strings facilitated the finding of the sacks. Sacks were placed in a like manner on the crest of the levee and midway down the side for checks. The garden centipedes were placed in the soil December 30, 1935, and the area was not treated until January 27, 1936, to allow for a natural settling of the soil due to rain and other influences.

Two ounces of carbon disulfide were added to holes 18 inches apart. The holes in alternate rows were staggered to minimize the distance the gas would have to diffuse through the soil. They were so placed that the sacks were located at the greatest diffusion distance. The holes were made to the depth of 6 inches. this including that portion of the hole made by the sharp-pointed probe. After the carbon disulfide was applied, the holes were tamped tightly shut. The sacks containing the garden centipedes were examined on February 2 and all the individuals in the treated area were dead. With few exceptions they had been recently

[1] This investigation was carried on in cooperation with J. W. Coover of the seed department of the California Packing Corporation.

killed, showing that death was due to the carbon disulfide. In the checks all the garden centipedes were alive with the exception of those at the 18-inch level in the series which was located midway down the levee. The soil at this particular spot was supersaturated with water and was the wettest of any encountered in the entire experiment.

This experiment clearly showed that the garden centipede can be controlled under rather adverse conditions, but because of the cost involved the treatment should be restricted to very special conditions. Because there is always a chance that all the pests are not killed by flooding, it is doubtful whether it would be practical to treat the levees under most conditions.

Summary.—Studies conducted in the delta of the Sacramento river have shown that the garden centipede, *Scutigerella immaculata* (Newp.), can be successfully controlled by flooding infested fields for a period of several days to a week in the summer.

Observations also indicate that cultural methods used in the growing of different crops have an influence on the garden centipede population, for instance, land cropped to sugar beets favors the pest more than land cropped to onions.

Calcium cyanamid had apparently little effect upon the garden centipede, but the application of the material might prove very beneficial if applied to soils deficient in available nitrogen.

Carbon disulfide was found to be very effective against the garden centipede even when applied to cold wet soil of a levee, if 2 ounces of the material were added to holes 18 inches apart, and the holes in alternate rows staggered to minimize the distance the gas would have to diffuse.—10-4-37.

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Physiology of Psyllid Yellows of Potatoes

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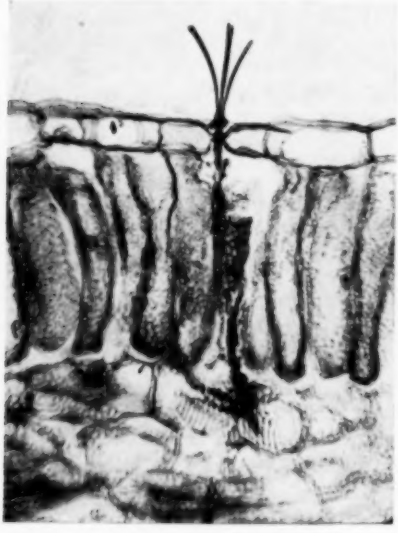
Several years ago the author published in the JOURNAL (Eyer & Crawford 1933) an article on the feeding habits of the jumping plant louse, *Paratrioza cockerelli*, which causes the "psyllid yellows" disease of Irish potatoes. This disease, as has been described by Richards (1933) and his coworkers in Utah, is characterized by the upward curling and yellowing of the older leaves, the purpling of the margins of the younger leaflets, enlargement of the nodes and petioles, rosetting and the production of axillary shoots and aerial tubers. Furthermore, the yield of the affected plant is exceptionally low, the tubers are small, borne on extremely long stolons, and tend to sprout prematurely. In many of these respects the disease resembles both leaf roll and rhizoctonia.

The disease cannot be transmitted mechanically through the customary inoculation methods nor is it carried over in the seed. It is produced

only by the feeding of the nymphal stages of *Paratrioza cockerelli;* the adults are incapable of producing it. Furthermore, no incubation period is necessary as is the case in most insect-transmitted virus diseases, and the nymphs need not have fed previously on infected plants in order to produce typical symptoms. Also, when the insects are removed, the plants exhibit entire or partial recovery provided they are not too near maturity.



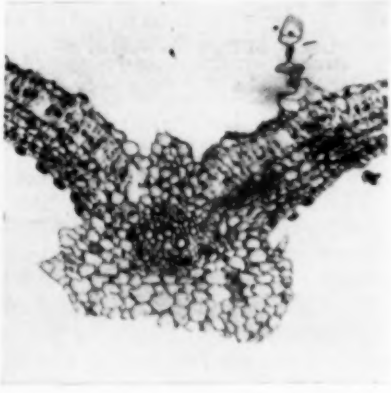


Fig. 1 (Left).—Cross-section of leaf blade, showing beak of potato psyllid nymph penetrating upper epidermis and palisade into tracheid.

Fig. 2 (Above).—Cross-section through midrib and leaf blade of diseased plant, showing necrotic phloem and distorted chloroplasts and nuclei.

From these facts, the nature of the disease seems to be that of a chlorotic toxemia produced entirely by an insect without the accompanying influence of a virus or pathogene. In an attempt to gain more information regarding the specific nature of this disease, detailed studies of both the anatomy and metabolism of affected plants have received careful consideration in our studies at the New Mexico Agricultural Experiment Station. Histological studies were first made of the feeding punctures of *Paratrioza* nymphs and revealed that the mouthparts are long and bristlelike, much as those of scale insects, fig. 1. In feeding they are thrust deeply into the leaf parenchyma, usually from the lower surface, and invade the veinlets and especially the border parenchyma which is particularly concerned with the temporary storage of those carbohydrates elaborated in the early phases of photosynthesis. The injury thus produced, aside from the mechanical rupturing of the cells and the withdrawal of carbohydrates, consists also of the breaking down of the cell proteins. This is evidenced by the detection, through microchemical analysis, of such disintegration products as arginine, tyrosine and tryptophane. As will be explained later, this protein disintegration is reflected in the reduced nitrate-nitrogen content of diseased as compared with healthy plants.

The injury to the border parenchyma seems to be extended laterally, at least to a limited extent, for sections through the midrib and petioles show necrosis of the phloem or principal carbohydrate conducting tissues, fig. 2. To what extent such injuries are affected by ferments or diastatic and oxidizing enzymes still remains to be demonstrated. That

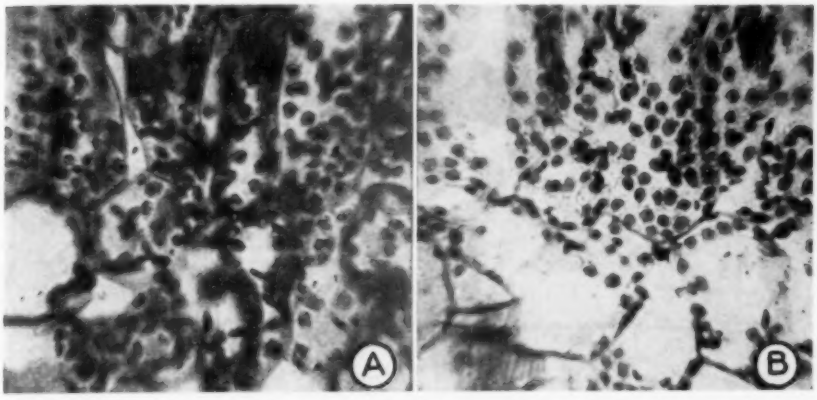


Fig. 3.—Chloroplasts in palisade and spongy parenchyma of a healthy leaf, *A*, as compared with those in a diseased leaf, *B*.

local translocation is inhibited, has been shown, and will be explained later in a discussion of the distribution of carbohydrates during the 24-hour period. The immediate effect of these injuries on the chlorenchyma is apparent through the smaller size, lighter pigmentation and distortion of the chloroplastids, fig. 3. In severely diseased tissues this results in almost complete disintegration of these structures with accom-

Table 1.—Pigment comparison, healthy and diseased foliage, 1936.

	Series 1 June 10	Series 2 June 12	Series 3 June 27
Healthy Foliage			
Total pigments (mg./gr. of plant material)	.0050	.0032	.0014
Chlorophyll A and B	.0038	.0021	
Carotin	.0009	.001	trace
Xanthophyll	.0003	.0001	trace
Diseased Foliage			
Total pigments (mg./gr. of plant material)	.0045	.0016	0
Chlorophyll A and B	.0037	.0011	0
Carotin	.0005	.0003	0
Xanthophyll	.0003	.0002	0

panying abnormalities in the shape and staining characters of the nucleus. Moreover it was found by quantitative analysis that the percentage of both chlorophyll and carotin are decidedly decreased by the disease, table 1.

Let us refer now to the studies of the carbohydrate metabolism. In the normal potato plant three types of carbohydrates can be easily detected and quantitatively determined. These are the hexoses (glucose and levu-

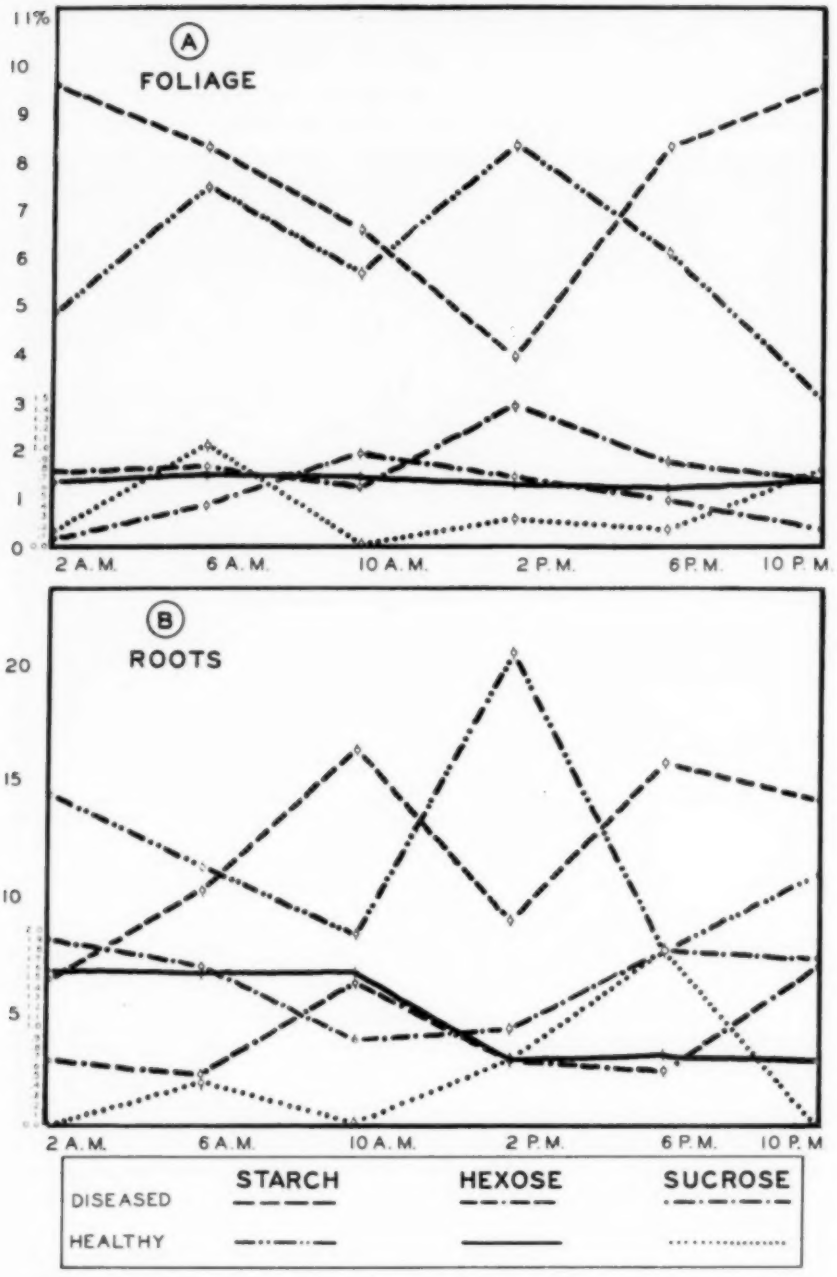


Fig. 4.—Variations in carbohydrates in leaf and root of healthy potato plant compared with a diseased plant over a 24-hour period.

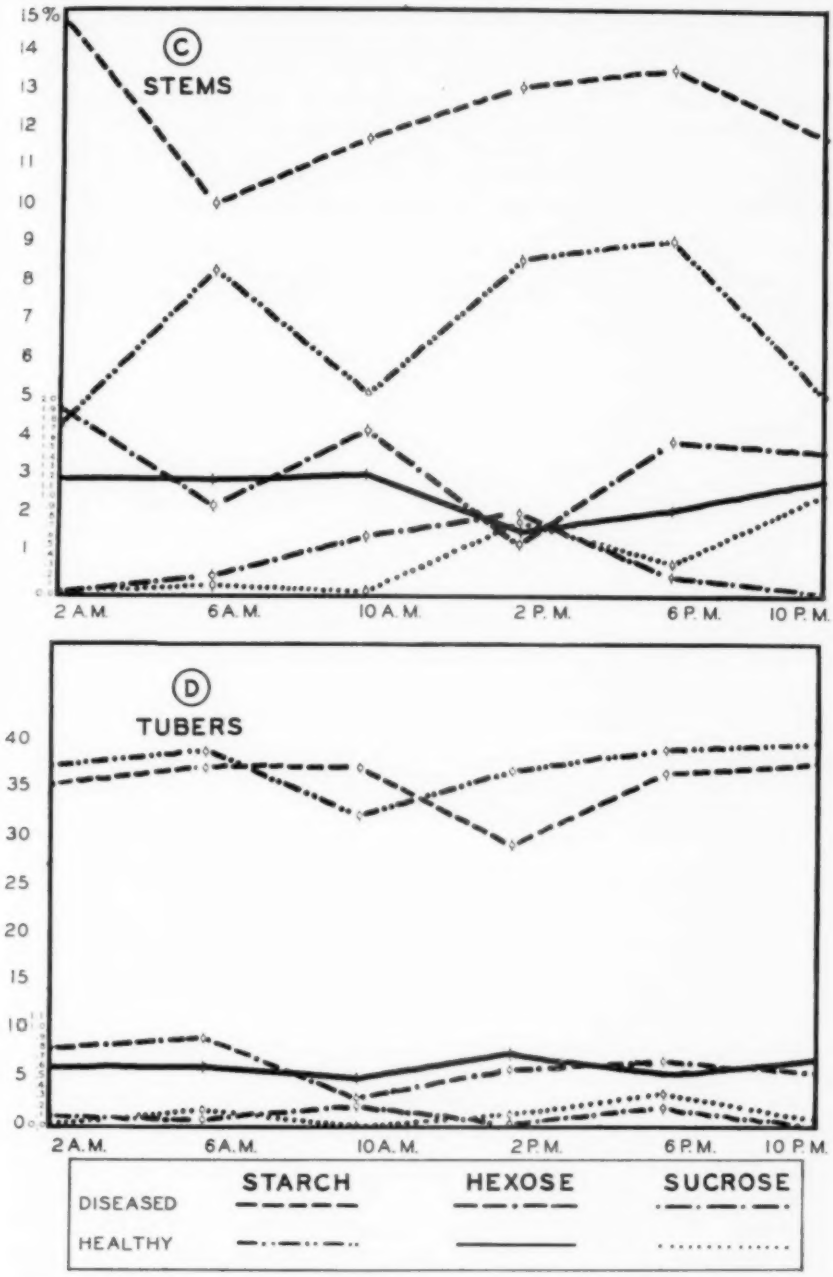


Fig. 5.—Variations in carbohydrates in stem and tuber of healthy potato plant compared with a diseased plant over a 24-hour period.

lose) which are the direct products of photosynthesis; sucrose, which according to Barton-Wright & McBain (1932, 1933) is the sugar of translocation and starch synthesis in healthy plants; and the starches which constitute in the potato both a temporary and permanent reserve.

Figures 4 and 5 compare the relative amounts of these three carbohydrates in healthy and diseased plants at four-hour intervals over a 24-hour period, as ascertained by the Shaffer-Hartmann method. Referring first to the healthy leaf, the analyses show that the formation of

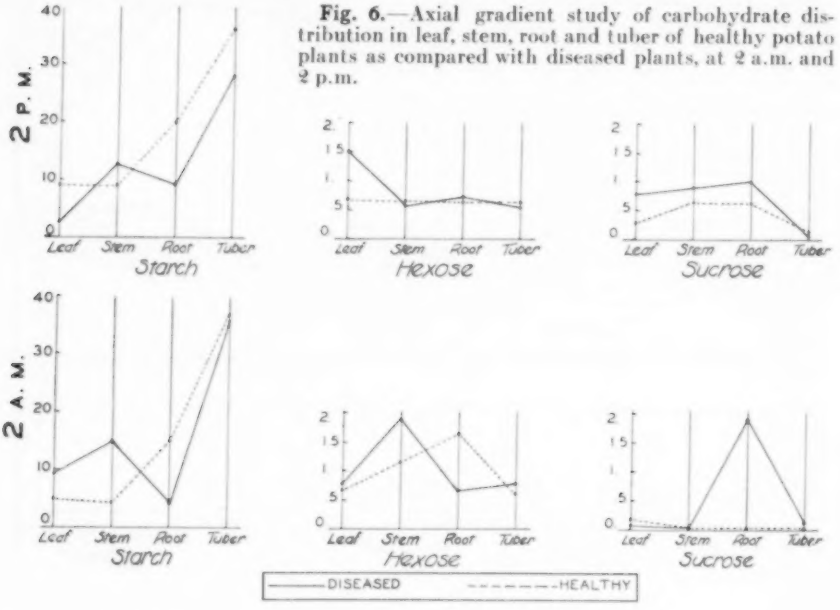


Fig. 6.—Axial gradient study of carbohydrate distribution in leaf, stem, root and tuber of healthy potato plants as compared with diseased plants, at 2 a.m. and 2 p.m.

hexoses is fairly uniform over the entire 24-hour period. In contrast, sucrose accumulates during the morning and evening hours and decreases through translocation and conversion during the mid-day period. Starches in the leaf accumulate with a fair degree of regularity during the sunlight period and become lesser in amount at night. The carbohydrate curves for the healthy stem advance progressively beyond those of the leaf, indicating normal translocation of soluble sugars and conversion to starch only to the extent that the excess of the former gives rise to the temporary storage. At the time the soluble carbohydrates reach the roots some 24 hours later, approximately the same relationship exists.

In the diseased plant conditions are decidedly different. First of all the hexoses do not form in the leaf as uniformly and an accumulation occurs during the afternoon hours, which is accompanied by a decided decrease in starch. The necrotic phloem, as demonstrated in the cross sections of the petiole, may account for these differences. The sucrose in the diseased leaf accumulates and translocation is delayed.

In the stem these fluctuations are even more marked, indicating a

tendency for compensation through more rapid conversion of hexoses into sucrose. The starch here apparently maintains a maximum concentration through conversion of the accumulated soluble carbohydrates, *e.g.*, hexose and sucrose. By the time the soluble carbohydrates have been transported to the roots the tendency for retention has produced a condition where the hexoses are decidedly low, due possibly to both faulty translocation and conversion to starch and sucrose. These relations are even more evident when axial gradient diagrams are constructed from the foregoing data, fig. 6.

Table 2.—Nitrate nitrogen content of healthy and diseased potato plants.

Treatment	Parts per Million Nitrate Nitrogen in .5 Gram of Potato Stems	
	Healthy	Diseased
Insecticides		
Bentonite sulfur dust	407	286
Bentonite sulfur liquid	323	228
Dry lime sulfur	420	334
Liquid lime sulfur	391	236
Nicotine–liquid lime sulfur	368	311
Untreated check	305	220
Fertilizers		
Ammonium sulfate–acid phosphate	289	182
Ammonium sulfate–acid phosphate–iron sulfate	538	234
Ammonium sulfate–acid phosphate–aluminum sulfate	420	204
Ammonium sulfate–acid phosphate–manganese sulfate	389	148
Untreated check	331	164

As has already been mentioned, the tubers of diseased plants are much smaller than those of healthy plants. Consequently when a direct comparison of the carbohydrates is made between healthy and diseased tubers the differences, as measured on a unit basis such as dry weight, are not as marked as might be expected. However, over the 24-hour period the storage of starches is significantly less in diseased tubers than in healthy.

Disintegration of the cell proteins in the region of the psyllid feeding punctures, as mentioned, was demonstrated through qualitative microchemical analyses. Thus far, time has permitted a preliminary investigation only of this phase of the plant metabolism. A series of field tests for nitrate nitrogen in the fresh tissues of healthy and diseased plants, using the methods of Emmert (1932) has, however, been made, table 2.

These tests included plants receiving different applications of commercial fertilizers as well as different insecticide schedules. It was found that no matter what treatment the potato plants received by way of fertilizers or insecticides, those plants which showed unmistakable symptoms of psyllid yellows were markedly deficient in nitrate nitrogen. Since it has been shown by Barton-Wright & McBain (1933) and Nightingale (1928) that this form of nitrogen represents a quickly available type used by most plants to elaborate vegetative growth preparatory for maturation, it is highly significant that this form is noticeably lacking in a dis-

ease like psyllid yellows, which is characterized by suppression of both normal vegetative growth and yield of marketable tubers.—9-10-37.

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Study of Control Measures Against Cotton Aphid

Wu, Chen-chung,[1] *Central Cotton Improvement Institute National Economic Council, Shiao-Ling-Wei, Nanking, China*

The following is a summary of Mr. Wu, Chen-chung's paper, and is given here so that the American entomologists can have a better understanding of the problems that confront the Chinese entomologist. The work deals with the distribution, life history, causes of outbreaks, and control measures against the cotton aphid. The author's personal experiences in the extension of the new control measures in Hopei province, during 1936, are fully discussed.—A.E.M.

Losses due to aphids.—In North China, the cotton aphid, *Aphis gossypii* Glover, is the most serious insect pest of cotton, particularly the American varieties. Because of this some cotton growers strongly advise against planting foreign varieties. Young cotton plants are most severely infested and in cases may appear wilted, eventually dying. Plants that are only slightly infested recover after a heavy rain, but their yield is much reduced. The estimated losses due to aphids all over China totalled 30 million dollars in 1936.

Causes of outbreaks.—Dry weather and drought favor the development of the pest. The degree of infestation varies in the same field. The aphids usually first appear near the villages and spread from these centers to more remote places. If rigid control measures were carried out in the fields in the vicinity of villages, the spread of the pest could be checked with a minimum amount of work.

Control.—Best control measures consist in using contact insecticides. A soap stock and cottonseed-oil emulsion were found to give best results. Tobacco extract came next. From the standpoint of cost the soap stock is the cheapest. Cottonseed-oil emulsion costs about eight times as much, and the tobacco extract 30 to 40 times as much as soap stock.

[1] Associate entomologist. The author desires to express his hearty thanks to Mr. Woo, Fu-Cheng, chief entomologist of the same institute and National Agricultural Research Council, for the help and encouragement given during the progress of this investigation, to Professor E. O. Essig for his assistance in identifying the specific scientific name of the insect and to Dr. A. E. Michelbacher for his kindness in editing the present summary.

COTTONSEED-OIL EMULSIONS.—Although cottonseed-oil emulsion has been used for years, it was not adopted by the farmers to any great extent, because of its high cost. In the present investigation experiments were conducted to determine whether smaller percentages of cottonseed oil might be used and still prove effective. It was found that a .3 per cent cottonseed-oil emulsion gave excellent control. This reduced the cost of material per acre from 92 cents to 20 cents. An improved formula which is given below was developed by Dr. Yang, Show-chen, and Mr. Sun, Yun-pei, of the Department of Chemistry, of the Central Cotton Improvement Institute:

FORMULA

Water	15,000 cc.
Soda Ash (Na_2CO_3)	47 grams
Soap	31 grams
Cottonseed oil	47 cc.

Dissolve the soda and soap separately with a small amount of hot water, then add the soda solution to the 15,000 cc. of water. After 30 minutes add the soap solution and then the cottonseed oil. Stir continually for some time.

It was also found that cottonseed-oil emulsion was about eight times as effective as kerosene, that is, .3 per cent of the cottonseed-oil emulsion was as effective, if not more so, than a 2.5 per cent kerosene emulsion.

SOAP STOCK.—This is a by-product from the cottonseed-oil mill. The soap stock and the refined oil are obtained after the caustic soda solution is added to the raw oil. The soap stock is very cheap, costing only 66 cents for 100 kilograms. During 1936 this material was experimentally tested to see whether it was as effective as the cottonseed-oil emulsion. Careful experiments showed that 91 per cent of the aphids could be killed even when the soap stock was diluted with water 120 times. To make an emulsion it is only necessary to dilute the material with water. It is then ready for use and the cost of material is only 2 cents per acre. This is probably the cheapest insecticide found in the world.

METHODS OF APPLICATION.—Contact insecticides are usually applied with sprays. Late in 1936 the author suggested a new method whereby infested cotton plants are dipped into a container filled with the insecticide. This method has been named the "dipping method" and proved to be very effective. This means of control was readily adopted by the farmers, where so advised.

METHOD OF EXTENSION.—Because the farmers are usually very dubious, demonstration methods were used in Hopei during 1936. A demonstration farm of $16\frac{2}{3}$ acres was established in each of the three following districts, Li, Chin and Chao. Although doubtful at first the farmers were quite surprised at the satisfactory results obtained. Within one month 164 villages adopted this method of treatment and control was effected on more than 2500 acres of infested cotton.

RESULTS.—According to the report of the Ting Hsien Cotton Experiment Station there was an increase of 144 to 300 pounds of cotton per acre in every field that was treated. The increased yield reported by the Tung Shan Hsien Agricultural Experiment Station was 576 pounds per

acre. The average increase reported from these two stations is therefore 332 pounds or about $19 per acre. The increase in yield on the 2500 acres makes an additional income of $50,000, while the cost of the insecticide was slightly more than $2000.

Future Plans.—Since July 1936, the Hopei government has been very interested in this treatment. Seventy thousand dollars has been appropriated to extend the program. There has been issued a command that all farmers must adopt this method of controlling the aphid.

The Central Cotton Improvement Institute held a meeting in Keifeng, Honan, of all the members of the various cotton experiment stations in the different provinces, and taught them the control measures. All the provincial experiment stations in north China have readily adopted this method on a large scale. It is expected that control will be carried out on 660,000 acres in 1937 and 3,330,000 acres in 1938.

A New Gooseberry Pest, *Stretchia plusiaeformis* Hy.

JOHN L. HOERNER, *Colorado State College, Fort Collins*

With respect to *Stretchia plusiaeformis* Hy. we have apparently found another example of a native insect having become a pest of a cultivated crop. In the insect collection of Colorado State College this species is represented by three specimens taken at a light by Dr. C. P. Gillette. One is recorded from Fort Collins, March 25, 1892, and two from Denver, April 30, 1892. Very little or nothing is known about this insect or its food plants.

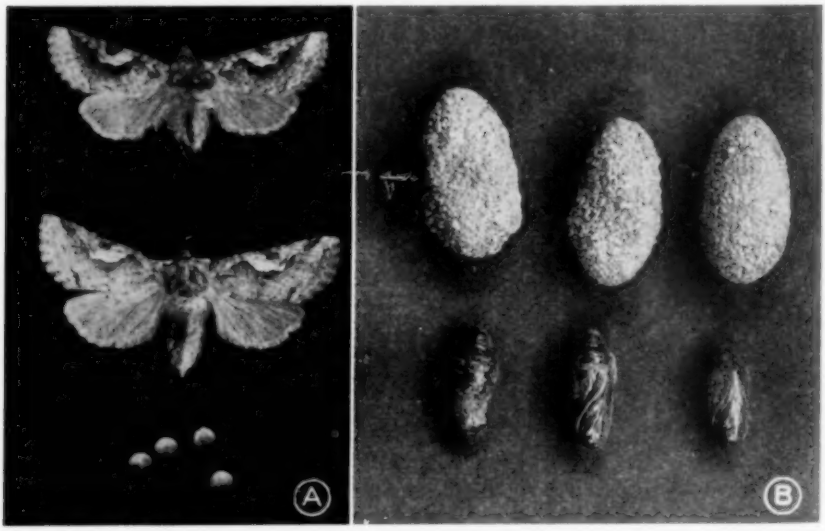

Fig. 2.—Moths, eggs, pupal cases and pupae of *Stretchia plusiaeformis* Hy.

Fig. 1.—Larvae of *Stretchia plusiaeformis* Hy. and the injury it causes to gooseberries.

In 1931, Mr. Hepler, a representative of the Libby-McNeill & Libby Canning Co. at Manzanola, Colo., called attention to the fact that gooseberries grown in that section of the state were being injured. From his description it was suggested that probably the damage was caused by the currant fruit fly or the gooseberry fruit worm as reported from Utah.

In 1932, the writer was in that part of the state and was sent to investigate. The writer was looking for the gooseberry fruit worm moths during the blossoming period but found none. Later, injured berries were received and a second trip was made. This time numerous cutworms were found in the bases of the plants among the dead leaves. These worms were active at night, crawling up the plants, cutting holes in the sides of the berry and eating out the seeds.

Numerous worms were collected and reared. The moths were determined by Foster H. Benjamin, of the U. S. Bureau of Entomology and Plant Quarantine, as *Stretchia plusiaeformis* Hy.

Life cycle.—The moths emerge the later part of March and the first part of April. The eggs are deposited on the twigs and buds. The eggs hatch in seven or eight days and the young larvae feed on the expanding leaves. At about the third instar, the larvae seek shelter in the leaves and ground at the base of the plants. When the larvae are about full grown they seem to prefer the seeds of the developing berries. These are obtained by cutting a neat, clean hole in the side of the berry. As much as 90 per cent of the berries have been injured. When full grown the larvae enter the soil, make pupal cells and pupate within. They remain in the pupal stage through the summer and winter, and emerge as moths early the next spring. There is one brood a year.

Best control was obtained by the use of 3 pounds of lead arsenate in 100 gallons of water, applied just as the leaves are expanding. In severe infestations, a second application may be necessary about 10 days later.

Poison bran mash, containing bran, Paris green and molasses, gave some control, but was applied just about the time the larvae were entering the ground to pupate.

Trimming off the lower branches of the bushes and close cultivation through the summer apparently aided greatly in reducing the injury the following year.—10-4-37.

Peach Mosiac Disease in Colorado

CARROL W. WADE, *Colorado Division of Agriculture, Denver*

Peach mosaic is a disease of recent occurrence in Colorado, having been first recorded July 12, 1931, in Mesa county by E. W. Bodine, associate botanist of the Colorado Agricultural Experiment Station. At that time seven trees in three adjoining orchards were found to be affected. The disease was further observed in subsequent years, and on May 14, 1934, it was identified by Bodine and confirmed June 19 of the same year by Dr. Lee M. Hutchins of the U. S. Department of Agriculture (Bodine, Hutchins & Thornberry 1937). At present the disease is found in five other states.

Early spring symptoms of mosaic in Colorado are the backward or delayed development of the leaves. At that time the disease can be very easily detected on the leaves. In most cases the leaves are small, narrow, crinkled, irregular in outline and definitely mottled with dark green and light yellow mosaic patterns, fig. 1. As the leaves grow the mottling becomes apparent over the whole leaf area; however, the mosaic patterns may become less distinct in all varieties as the season progresses.

Trees that have been heavily diseased for more than one year will produce an abnormal twig growth with shortened internodes. This results in a bunched, stunted leaf growth which is definitely associated with the abnormal leaf characters.

Fruit on diseased trees ripens somewhat later than that of normal healthy trees. Within six weeks after blossoming time most of the diseased fruit takes on a bumpy and ridged appearance which develops more distinctly as the season advances. Diseased fruit that is distorted and small is unfit for market.

The eradication program for Mesa county in Colorado began in 1934 through a request from growers. Throughout that fall, mass meetings of all peach growers were held to familiarize them with the disease and to

Fig. 1.—Mosaic-affected leaves, showing characteristic mottling and veinlet clearing. Normal leaves are at extreme left and right.

bring to light its serious threat to the peach industry. A preliminary survey was conducted at that time and 6000 diseased trees were marked, many of them being taken out by the growers. An advisory committee was then chosen by the growers to represent them in the program and to help work out the plan of control. Further at the request of the growers a pest district was formed by the state and the eradication program started in the spring of 1935.

The entire district was mapped to show townships, ranges, sections and properties. After this, scouting crews were organized and the property cards of an entire section were assigned to the crew supervisor. Each peach tree in the area was checked and all diseased trees found were chopped down, dug out and burned. Accurate records were kept of all trees and properties inspected. Thirty-two thousand one hundred sixty-three diseased trees were found and removed during 1935.

In 1936 the same plan of work was followed. Diseased trees numbering 10,945 were found and destroyed on the 1271 properties inspected during three surveys. This is relatively a 66 per cent reduction of the disease for 1936 over 1935.

In 1937 the same work program was being carried on, three surveys of the area being conducted. The first survey revealed 3191 diseased trees among 653,273 inspected, second survey 195 diseased trees out of 427,758 inspected, and on the third survey 116 cases out of 154,355 trees inspected in the heavily diseased areas. The eradication program of 1937 has reduced the disease 68 per cent over 1936. Peach growers of the infected areas are well pleased with the entire eradication program and the progress that has been made. Reduction of the disease has been made possible only by having full cooperation of the growers, the fruit associations, the state agricultural experiment station, the federal Bureau of Entomology and Plant Quarantine, the WPA allotments and the state Bureau of Plant and Insect Control.

Presence of peach mosaic in Colorado has not hindered the planting of new orchards, for at present there are around 125,000 more trees in the Palisade district than there were in 1934 when the disease was first noticed in abundance and the eradication program begun.—9-10-37.

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Problem of the Range Grasshopper

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Control of grasshoppers on cultivated crops was first undertaken in America about 50 years ago and it is almost needless to add that it was not very successful. In fact, it was well towards the end of the last century before the biological facts were available upon which satisfactory method could be devised and well into the present century before these methods were in use.

Since that time much work has been done and many studies made under various local conditions, until at the present time it can be safely stated that with our present knowledge a grasshopper outbreak in the irrigated valleys of the west is an indication of individual or community ignorance or indifference. In other words, any community that so desires may reduce the grasshopper population below the injurious limits and hold it there indefinitely.

The situation is not that far advanced in the great plains and western edge of the prairie states, the region that is just witnessing a tremendously destructive outbreak. Here the situation is seriously complicated by the presence of large areas of submarginal lands—in fact, the recent grasshopper danger map put out by the government might be used for a map of the submarginal land problem.

Good rich farm land well plowed and cultivated does not normally

raise grasshoppers—good grass sod, either short grass or prairie, does not raise the kinds of grasshoppers that attack cultivated crops—even typical desert areas do not raise grasshoppers that injure the farmers' crops. But let any of these lands be cultivated and then abandoned, or let them be overgrazed and eroded and they immediately become hotbeds of weed production and grasshopper incubation.

Let us then recognize that we have *three* major grasshopper problems, not one.

First, the grasshoppers of the dust bowl and its environs, with its overgrazing, erosion and abandoned lands; a problem requiring many other agencies, besides entomological ones to solve.

Second, the grasshoppers of the western irrigated valleys, especially where these irrigated valleys are clear-cut and limited to rich irrigated lands with deserts or grasslands alongside. The problem here is relatively simple and requires only individual and community attack. The outstanding successes in the past in checking outbreaks and in inaugurating farm practices that have kept these pests from reappearing indefinitely should point the way to better success in the Mississippi valley, even under dust bowl conditions.

Third, the range grasshopper problem. This has not been a problem in the past, simply because no one knew enough about the biology of these forms or of the possibilities or opportunities of modifying the environmental factors, to attempt to attack it. We are in about the same place with this problem that we were in the early seventies with the farm grasshopper problem.

The writer (Ball 1936) has already called attention to the fact that his work on the biology of grasshoppers of Colorado and Arizona indicates that there are about 130 species in each state, that of this 130 species not more than five or six are of major importance in attacking cultivated crops and that preliminary studies indicate that not more than 10 or 12 species in a given area will be of major importance in attacking the range grasses. Some 40 species have been proved to be beneficial, some highly so because they destroy the worst weeds of the range. This leaves 70 species that are either so rare as to be of no importance or which feed upon plants of little value.

To summarize, we find about six species of grasshoppers injurious to cultivated crops, because they are omnivorous and will feed on any crop. They are also all long winged and migratory, or partially so, which enables them to go from field to field and farm to farm. On the other hand, the serious range grasshoppers are all grass feeders and most of them are limited to a single grass or a few related species, rarely attacking cultivated crops. They are mostly shorted winged and even the winged forms are not migratory, but remain all their lives in a restricted area. While the range problem deals with a large number of plants, varied environmental factors, inaccessible terrain and a multiplicity of parasites and predators it is not complicated by the migratory habit of its major species.[1]

[1] The pellucid grasshopper is migratory, but it is largely confined to mountain meadows and not normally a pest on the open range. *Dissosteria longipennis* is attracting much attention at present, but is extremely local and sporadic in appearance.

The average man, upon being confronted with the problem of controlling range grasshoppers, would throw up his hands at once and say that it could not be done, that the area is so vast, the returns per acre so low and the terrain so broken and difficult that it would be sheer folly to attempt it—and it would be—for him to try it, or for anyone who contemplated relying upon using the methods applied on cultivated fields. These methods have been worked out for fields and the conditions found in fields. The field or farm is not a balanced biological entity, the plow alone upsets all that; crops do not succeed themselves; there is no continuity or climax. There is even less opportunity for many forms of parasites and predators. A parasite may build up only to have the crop harvested and the continuity broken; a predator may become established only to have the crop shifted; we do not depend upon biological control on farm grasshoppers. We used to depend largely on brute strength and awkwardness; lately we have degenerated another step and fall back upon government surveys and government poison. If we keep on we will probably have government hatcheries to furnish the grasshoppers so that the surveyors and poisoners will be certain of a continuous job and a more abundant life.

That may be an extreme point of view—possibly was intended to be, if so, only to remark that the writer recognizes that the government surveys and government poison have no doubt been of immense benefit in many areas, but he also recognizes that on the whole it has been exceedingly wasteful and inefficient and that a much smaller sum of money wisely expended on long-time biologic research into the possibility of more efficient and less costly methods of handling the problem, would probably yield much greater returns. Possibly out of all this agitation and hullabaloo may come just that—if so, it may be worth its price.

It might be worth while at this time, however, to suggest that the probable reason why the western irrigated valleys have been more successful in handling their grasshopper problems than their neighbors in the environs of the "dust bowl" has been largely because they have worked out a combination of cultural and biologic methods of control applicable to their conditions and much cheaper and more effective than the present tendency to rely on poisons, much of which has been applied after the damage was done.

In striking contrast to the situation on the farm, the undisturbed range *is* a balanced biologic entity and while many ranges by overgrazing and erosion have been more or less altered, still they are essentially a product of natural forces and still operating under those forces. That means that the approach to the range grasshopper problem must be on an entirely different basis from that usually employed upon the farm, that in general the control measures utilized must be to emphasize and encourage or expand that part of the natural pressure that ordinarily reduces the annual crop of grasshoppers to the relatively few that nature allows to survive.

Anyone attempting to utilize these natural forces in grasshopper control either on the range or on the farm, must constantly keep in mind certain fundamental factors, and work with and not against them. Some of the most important of these are:

Grasshoppers not static but cyclic.—They build up in a series of favorable years to devastating numbers; and usually drop back to minimum numbers even more rapidly, often in a single season.

The extreme possibilities or even the normal rate of multiplication under favorable conditions in nature has not been worked out for any of our species but enough is known so that all workers will agree that the table 1 is conservative; most of them will suggest that it is too conservative.

Table 1 is based on the assumption that it takes a pair to mate and lay eggs, that the female will lay two or probably more egg pods on the average, thus making the contents of a normal egg pod the minimum rate of possible multiplication.

From the table it will be seen that with even as low a rate as 25 eggs

Table 1.—Possible grasshopper multiplication under extremely favorable conditions.

	Egg Production per Each Original Grasshopper		
	First Year	Second Year	Third Year
Melanoplus mexicanus	25	600	15,000
M. differentialis	75	6,000	500,000
Schistocerca spp.	100	10,000	1,000,000

per pod that the third year might see 15,000 eggs deposited for every single grasshopper present the first year, while the large grasshopper, *M. differentialis*, might have half a million and the big bird locust a million. This table also shows why outbreaks often start with *M. mexicanis* and *femur-rubrum* the most abundant and reaches a climax with many times as many of the larger species.

Local predators of greater value in years of scarcity.—The majority of the local predators multiply rather slowly (as compared with the possibility in grasshoppers) and as they are equipped to hunt their food they get all they want except in years of extreme scarcity. They may eat two or even three times as many grasshoppers in years of abundance but that does not even make a dent in the swarms present at that time. On the other hand, in years of scarcity they may seek out and destroy the entire remainder in many areas and leave but a remnant in others so that the grasshoppers must build up in these local areas and then gradually spread back to the others before a general build-up in numbers can start.

Migratory predators, parasites and diseases usually more important in times of abundance.—Migratory predators (largely birds) rarely pay any attention to grasshoppers in areas wherever they are limited in numbers, but when they find an infested area they will alight and the ones passing over will see them feeding and swarm into the area by the thousands and in this way mop up an extensive outbreak.

The parasites have difficulty in reaching a grasshopper or other insect in rich vegetation, but let them destroy the grass or crop cover and immediately they become easy marks for many parasitic forms. The diseases of insects are frequently limited to favorable atmospheric condi-

tions for their destructive sweeps, but there is also a high correlation with the presence of unusual numbers of the host.

Usually favorable climatic cycles initiate grasshopper outbreaks, but predators, parasites and diseases as often terminate them.—Since the west was settled and records kept, there have been 11 or 12 grasshoppers outbreaks, about five of which have been widespread and destructive. Those of the early seventies and the early twenties of this century were probably the worst and most definitely marked, unless the present outstrips them, but the outbreaks of the late fifties and early sixties and the late nineties were widely destructive. Sporadic records before this time, as well as the record of the grasshopper glacier, indicate that these periodic outbreaks are normal and are correlated with climatic cycles. Besides these, there have been many local outbreaks with shorter cycles and some spots with almost chronic infestations. We need much more careful study into the conditions that initiated and terminated these outbreaks, as well as a critical study of biologic and climatic conditions in areas in which there have been no recorded outbreaks.

Hot and dry weather at egg-hatching time is recognized to be the most important favorable condition in general and in the more humid parts of the upper Mississippi valley this continues to be considered the most favorable variation but in the more arid parts of the great plains and especially in the southwest continued droughts may be so severe as to prevent hatching or to kill off practically the entire population that did hatch.

Some of these factors equally applicable to economical and efficient control of farm grasshoppers and other pests.—There have been relatively few comprehensive biological studies of important pests, but the majority of those studied have shown that cooperation with natural forces is an important part of efficient and economic control. The spring disking of ditch banks and fence rows for the destruction of grasshopper eggs has long been good farm practice in the Colorado-Utah irrigated regions, but the sowing of these areas to oats so as to produce dampness and shade at the time the remaining grasshoppers hatch out doubles the efficiency of the practice and has often resulted in the elimination of the pest. Under the extremely arid condition of the southwest, neither one of these practices would be of any value, but with a knowledge of the factors controlling, others of equal efficiency can be substituted.

Concrete examples often more illuminating than abstract principles or deductions.—To high-light the presentation the following are offered. The slopes of the Baboquivari mountains are one of the best grazing areas in the southwest. Some years ago Carlos Ronstadt, whose holdings are on that range, informed the writer that the area he had reserved for winter pasture that year had been eaten out by grasshoppers. When the writer visited the area early the next summer he found a bad infestation of "Boopee," *Boopodon nubilum*, the most injurious range grasshopper of the southwest. There were about a dozen grasshoppers per square yard. There were also a number of large heavy-bodied hawks (Swainson's) scattered over the area and the cowboys were shooting the hawks. When asked why the shot them they answered "The hawks eat the mice and the mice eat the grasshoppers." When it was explained and demon-

strated to them that the hawks were eating grasshoppers the shooting stopped. A visit two weeks later showed one-third as many grasshoppers and 10 times as many hawks. Two weeks later there were no grasshoppers left on the open range and no hawks at all. Down in the richer swales where the grass was rank the hawks had not been able to dislodge all the hoppers and there were a few Boopee left. Twice since that time, Boopee has built up populations large enough to be alarming, but each time the migrating hawks assisted by other migratory birds have found them and cleaned them out. The writer estimated 300 hawks to a square mile over an area of many square miles.

The Sulphur Springs valley is the largest in southeastern Arizona, being about 100 miles long and 20 miles wide. This valley is bordered on the east by a series of mountain chains, the Chiricahuas being the central and largest of these. Over these mountains for three days in the summer of 1932 rolled a series of fog clouds, probably the last remnants of a Gulf hurricane. These clouds were dissipated by the desert heat and never reached the farther side of the valley but on the eastern slope the humidity was high and a week later more than two-thirds of the then abundant grasshoppers the writer was studying were found dead of a fungous disease and still more succumbed in later rains, so that the population has not yet built up to its former maximum. Up to the time of the fungous outbreak the ravens had not been much in evidence in the open valley but after that the writer found that if he wanted to locate an area where the grasshoppers were abundant all he needed to do was to be in the valley early in the morning and watch the ravens spread out from their roosts in the Chiricahua mountains. Wherever any number of them alighted, there would be grasshoppers. These ravens went about their work in a strictly businesslike way. They would form rows spaced about $2\frac{1}{2}$ feet (the ordinary jump of a grasshopper) from each other and march along, paying no attention to a grasshopper that jumped away from them, but pouncing on one that jumped away from the other raven towards them before it had time to get its balance. Sometimes there would be a rear rank and occasionally a third row, usually the birds in the second and third rows followed the openings in the row ahead. The $2\frac{1}{2}$-foot spacing was often maintained between rows but there was frequently greater irregularity in this than in the lateral spacing.[2] The activities of the ravens and other predators reduced the grasshopper population of the west side of the valley down nearly to that of the east side before the season was over.

In spite of the arid climate the fungous disease has made its appearance somewhere in the state nearly every year. It can usually be found in the shaded areas in the river bottoms, especially in the Santa Cruz valley. *M. differentialis* occurs in rich damp bottoms and this fungus is an important factor in its control in such areas.

The tarantulas and other large spiders appear to be important factors in grasshopper control. Because they are nocturnal, one does not ordi-

[2] The raven's actions and that of the grasshopper in jumping sidewise leads one to wonder if grasshoppers usually jump sidewise because they have learned that to jump ahead of a grazing animal means continual jumping, while one side leap will usually be sufficient. Lizards often parallel the course of a grazing animal and pick up grasshoppers. The writer has noted two instances where they paralleled his sweeping activities in grass and has watched them grab a grasshopper just as it struck ground, paying no attention to those too far away to pounce on at the critical moment.

narily realize their abundance. The writer was caught in a car in a sudden downpour on a heavily grassed range. The entire area was nearly 2 inches deep in water in a short times and as soon as it ceased he started out to see how the grasshoppers were reacting to the flood—they were climbing up on the grass stems apparently little the worse for the wetting but the interest soon shifted for about every 10 or 15 feet over the area was a big tarantula waiting for the water to disappear so he could go back down his silk-lined hole. The holes are usually under a tuft of grass and not noticed unless a search is made, but the writer has found since, that where the grasshoppers are abundant the holes are usually numerous.

The praying mantids, of which the southwest has seven species, the ground beetles, the robber flies, sarcophagids, the bee-flies, the blister beetles, the hair snakes and the mites all take their toll of the grasshopper and should be encouraged.

Grasshopper outbreaks are usually local in the beginning and if discovered early enough sheep or cattle can be concentrated on the area and the vegetation grazed off. This will trample and maim many and will expose the rest to the full force of the predators and parasites. If the grazing is sufficiently prompt and severe, it may starve the young ones to death. The writer has made counts (if you could call them that) of two to three living grasshoppers to a square mile on badly overgrazed drought-stricken areas.—9-10-37.

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Aphid Taxonomy as Related to Economic Entomology and Plant Pathology

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At first thought it might seem that an aphid is just an aphid and whether *Aphis rumicis* L., *Myzus persicae* Sulz. or *Aphis pomi* DeGeer is not important to the control, since any infestation whenever noticed can be sprayed with nicotine sulfate and destroyed. The matter, however, is not always so simple.

Single-host aphids.—A knowledge of the aphid's identity and its hosts is essential to determine whether other kinds of plants are in danger of attack. Most aphids feed upon only one species of plant or on species belonging to a single genus, and there is no danger of these aphids causing injury to other plants which may be near by. Out of 310 species of aphids recorded in Colorado, 226 are thus restricted in their feeding habits and 30 of these are economic species. For example, *Macrosiphum rudbeckiae* (Fitch), the red aphid on Golden Glow, does not colonize on anything else, *Clavigerus bicolor* (Oest.) and *Clavigerus smithiae* (Monell),

the large reddish or purple aphids which infest willow trees and are conspicuous on sidewalks or ground under them in the fall, will attack only willow. Other examples are *Periphyllus negundinis* (Thos.), the little green aphid on box elder, *Aphis pomi* DeGeer, the green apple aphid on apple, *Macrosiphum rosae* (L.), the green rose aphid, and the large brown aphids on conifers.

Alternate-host aphids.—Certain other species have alternate hosts, *i.e.*, a winter host, usually woody, and one or more summer hosts, usually herbaceous. Forty-four such species (17 of them economic) occur in Colorado. For example, *Myzus persicae* (Sulz.) winters on peach, damaging the fruit and curling the leaves in the spring, then migrating to a large number of herbaceous plants for the summer. *Rhopalosiphum prunifoliae* (Fitch), the apple grain aphid, winters on apple and spends the summer on oats. *Aphis bakeri* Cowen, the clover aphid, winters also on apple, but summers on clover. *Macrosiphum solanifolii* (Ash.), the potato aphid, winters on rose and summers on potato, cucurbits, peas and a large variety of other herbaceous plants.

Polyphagous aphids.—Other species are polyphagous, infesting a large variety of plants, still within certain limits. There are 13 such species in the state, mostly economic and introduced species. Examples are *Aphis gossypii* Glover, the cotton and cucumber aphid, which includes 11 families of plants in its bill of fare, as does also *Aphis medicaginis* Koch. *Aphis rumicis* L. includes eight families. *Aphis middletonii* Thos. six families, *Aphis marutae* Oest. eight families and *Myzus persicae* Sulz. in summer eight families besides the peach for winter host. Intelligent control of this group, of course, requires knowing the species concerned.

Alternate-host migrants.—Life history data are also important so as to know not only what hosts may be attacked but just when the aphid will be leaving the plant under consideration. The time of migration may decide the question as to whether control is needed. It is useless to spray aphids which are about to leave unless it is done to protect the alternate host. For the latter purpose the spray should be applied before any aphids have migrated. These dates are usually about the middle of May, for first appearance of migrants and around the middle of June for the final disappearance of the species from the first host; but this may vary with the different species as well as with the climate. Dates given here are from Colorado records, mostly from the vicinity of Fort Collins, but many are from the fruit-growing sections of the western part of the state. *Aphis helianthi* Monell, the sunflower aphis, leaves *Cornus* sp., the winter host, in the second generation, during the period beginning April 14 and ending May 4; *Aphis viburnicola* Gill. migrates in the second generation and from May 14 till about June 9, *Myzus persicae* (Sulz.) migrates mostly in the third generation from the beginning to the middle of June; *Rhopalosiphum prunifoliae* (Fitch), May 1 to June 22, and *Myzus cerasi* (Fab.) June 8 to early July; *Aphis helichrysi* Kalt. finishes not later than the middle of June; *Hyalopterus arundinis* (Fab.) begins migrating to grass (*Phragmites communis*) about May 25 but does not migrate completely, some remaining on the plum all summer.

Single-host migrants.—Aphids remaining on the same species of host have certain periods when migrants appear and spread the infestation.

Control measures should be applied before this date. The winged forms usually appear during the latter part of May, but some species vary from this, *e.g.*, in *Aphis persicae-niger* Smith on peach, winged forms appear April 29 and by June 13 the colonies have disappeared. *Aphis pomi* migrants appear April 18, but mostly from May 10 to Sept. 1. In *Aphis rubicola* Oest. the winged forms may not appear before June 2. In the case of *Eriosoma lanigerum*, the wooly apple aphis, winged forms are extremely rare till beginning of September.

Plant deformities.—Some species of aphids produce plant deformities such as leaf curl or galls which protect them against sprays and dusts used as control. In these cases, by the time the infestation is noticeable nothing very effective can be done. With such species the measures must be preventive to be successful. Recognition of the presence of the eggs and knowledge of the time of hatching is necessary so as to apply the spray between the time of the hatching and the opening of the leaf buds where the little aphids will be able to find protection in the folded and later curled leaves. Examples of such cases are *Myzus cerasi*, the black cherry aphid, in late May and June; *Myzus persicae*, the green peach aphid, before May 23; *Aphis viburnicola*, snowball aphid, in early May, and *Prociphilus fraxinifolii* Riley which curls ash tree leaves into unsightly clusters.

Plant disease carriers.—Plant pathology involves knowledge of identity of aphids in the control of virus diseases. A certain comparatively small number of species of aphids are carriers, while others are innocent. A knowledge of identity of species found on diseased plants is necessary to determine their part, if any, in the trouble and to aid in discovering any possible sources of additional infestation and infection.

Some plant disease viruses are carried by a single species of aphid, others by several. For example a disease transmitted by a single aphid species, as perhaps raspberry curl disease, carried by *Aphis rubicola* (Oestlund), or red mosaic of raspberry, carried by *Amphorophora rubi* (Kaltenbach), requires recognition of those respective species only and as their only hosts are plants belonging to the genus *Rubus* there is no danger of carriers arising from aphid infestations on other plants. On the other hand, leaf-roll of potato has been reported to be transmitted by a half a dozen or more species of aphids, first and foremost *Myzus persicae* (Sulz.) but also *Macrosiphum solanifolii* Ash., *Myzus circumflexus* (Buckt.), *Macrosiphum pelargonii* (Kalt.), *Aphis fabae* and possibly *Myzus pseudosolani* Theobald. Most of these species infest a large variety of hosts, including many weeds and truck crops. Recognition of these aphids, whether on the potato or on neighboring plants including weeds, is therefore very important for the purpose of reducing carriers and controlling the spread of the disease.

Host and aphid keys.—A practical key for the use of the economic general entomologist and growers would seem very desirable. The general aphid keys are highly technical and often use characters which are difficult for even an aphidologist to determine. It is necessary to know the large groups at sight, for keys to the subfamilies, in order to include exceptional cases, are driven to use characters not present in all stages, or difficult to observe, especially for one not a specialist. A host key can

simplify the problem greatly because it includes only the species commonly found on the host in question. A field key can use color of aphid, presence or absence of wool, whether solitary or in colonies, part of plant attacked and character of plant deformity, if any. Of course these characters are not evident in preserved aphids and here microscopic characters must be used and these require more training. Beginning with the host greatly simplifies even this kind of key. This procedure, however, cannot include unusual or stray species of aphids and therefore is not entirely reliable. In the fall, return migrants often settle on hosts related to the true host and they may even deposit sexuales. Such collections can be determined only by an aphidologist.

Summary.—Knowledge of aphid identity is at least advantageous and often essential to intelligent and efficient control of aphid infestations. Keys beginning with the host and following with either field or microscopic characters may suffice for the use of general entomologists in a considerable proportion of cases, but there still remain a large number of cases which can be decided only by a specialist in aphid taxonomy. —9-10-37.

CURRENT CONTRIBUTIONS

Some Physical Properties of Commercial Paris Greens

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The particle-size distribution in 22 brands of commercial calcium arsenate was reported in a preceding paper by Goodhue (1937). The correlation of particle size with other physical and some chemical properties of this material appeared to be of such general interest that a similar

Table 1.—Particle-size distribution of nine commercial brands of Paris green.

SAMPLE	PERCENTAGE OF SAMPLES BETWEEN INDICATED RADII					
	Above 20μ	20–15μ	15 to 10μ	10 to 7.5μ	7.5 to 5μ	Below 5μ
A	24	30	33	6	5	2
B	16	14	33	24	10	3
C	32	14	27	12	6	9
D	32	22	36	4	2	4
E	11	14	26	24	13	12
F	14	4	32	27	14	9
G	12	10	14	15	22	27
H	10	6	18	16	15	35
I	8	8	25	32	23	4

study has been made of the commercial brands of Paris green. This includes the determination of five constants—the particle-size distribution, the particle form, the density, the loose bulking value, and the angle of slope—all of which in some measure characterize a dusting insecticide.

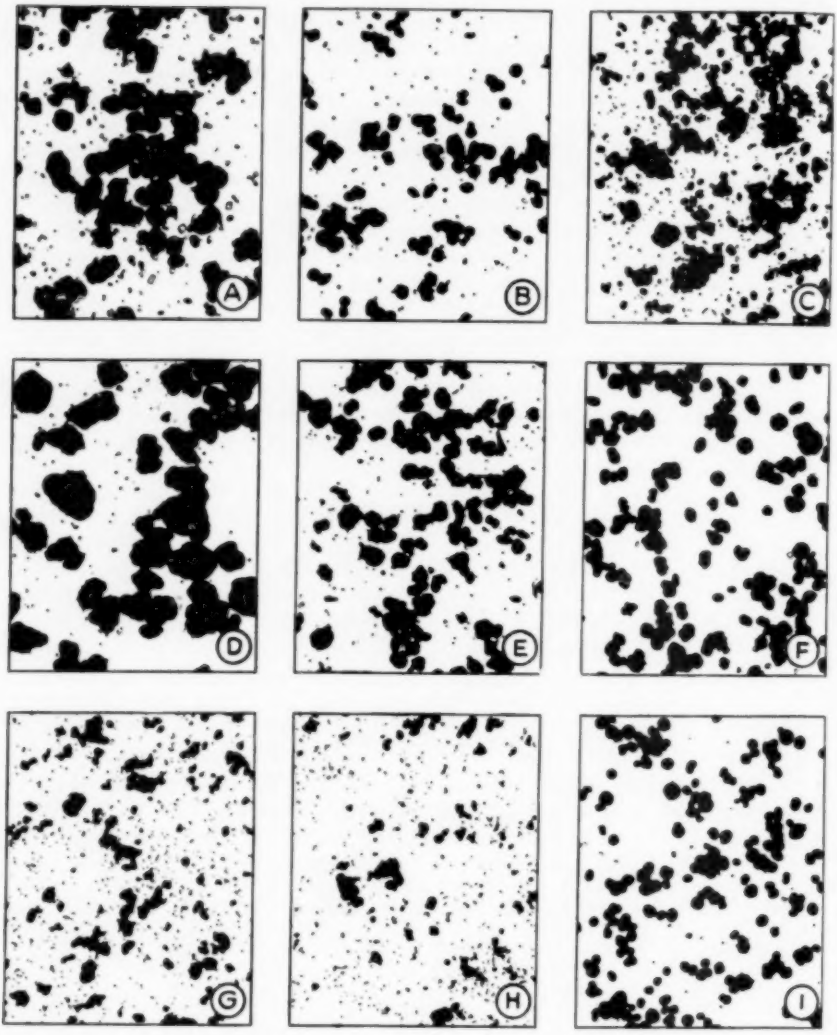

Fig. 1.—Photomicrographs (×100) of nine commercial brands of Paris green.

Particle-size distribution.—For the determination of particle size the method of sedimentation analysis as described by Goodhue & Smith (1936) was used. The suspension was prepared by shaking the sample for one hour in a dilute sodium citrate solution in 50-per cent alcohol. Upon final dilution in the sedimentation apparatus the concentration of the Paris green was 11.3 grams per liter, and of the sodium citrate .3 gram per liter. This amount of sodium citrate was sufficient to prevent flocculation. The Paris greens fall in a range that is well adapted to sedimentation analysis.

The particle-size distribution is given in table 1. To get as much information as possible, six fractions have been chosen, and the amounts falling in them have been calculated by the graphical method of Odén (1916, 1926). The amount above an effective radius of 20 microns should be comparable to the amount that will not pass a 325-mesh sieve.

Particle form.—To check the sedimentation results and to record the particle form each sample was photographed. At first slides were prepared by dispersing a small amount of the material in a drop of glycerin, but the high refractive index of the glycerin made it difficult to obtain photographs with sufficient contrast. Finally, a test-tube duster similar to the one described by McCallan (1930) was used to dust the slides and obtain the dispersion in the dry way. A comparison of a sample in glycerin with one in air showed very little, if any, difference in the degree of dispersion.

Table 2.—Some physical constants of nine samples of commercial Paris green.

Sample	Density* Grams per Cc.	Bulking Value Cu. In. per Lb.	Angle of Slope Degrees
A	3.21	17.9	36.2
B	3.21	18.9	34.7
C	3.20	20.2	36.7
D	3.24	21.4	31.8
E	3.21	20.0	36.2
F	3.19	20.0	37.1
G	3.26	24.8	32.7
H	3.30	27.7	49.3
I	3.18	21.2	31.1

* These values were determined by S. Love, of the Division of Insecticide Investigations.

Although the exact particle size was not determined from the photographs, fig. 1, the relative order of fineness is very close to that obtained by sedimentation analysis. With very coarse or very fine samples the photographs give an idea of the particle size above and below the range covered by sedimentation analysis.

In the manufacture of Paris green the tendency is for spheroids to be formed in the crystallization process. These are very evident in several of the samples, while in others only irregular particles could be found. The form characteristic of each sample can be readily determined from the photomicrographs in fig. 1.

Density.—The density was determined by the pycnometric method, 95 per cent alcohol being used as the immersion fluid. Since Paris green is a definite compound, the determination of the density gives some idea of the purity and the uniformity of different brands. The values for density, given in table 2, show little variation. As in calcium arsenate, the finer samples tend to have the higher densities, but with Paris green the correlation between particle size and density is not good.

Loose bulking value.—The loose bulking value was determined by weighing the contents of a container having a capacity of 9.15 cubic inches. The values appearing in table 2 have been converted to cubic inches per pound. Although the actual values do not vary so much as for the calcium arsenates, the percentage variation is nearly as great. In

the case of the Paris greens the bulking value gives a more reliable indication of the relative fineness than in the case of calcium arsenates. Except for sample D, which is somewhat out of order, the agreement is good.

Angle of slope.—Wilcoxon & McCallan (1931) measure the base angle of a cone formed by allowing dust to flow through a funnel supported above the center of a metal disc. When no further altitude is gained by further addition of dust, the height of the pile is measured and from the tangent the angle of slope is obtained. This angle gives a relative value for the dustibility of a dust. Dusts that flow easily and dust well give a low angle of slope. The values recorded in table 2 show that, except for sample H, the variation is not great. Usually Paris green gives an angle 15 to 20 degrees lower than calcium arsenate.

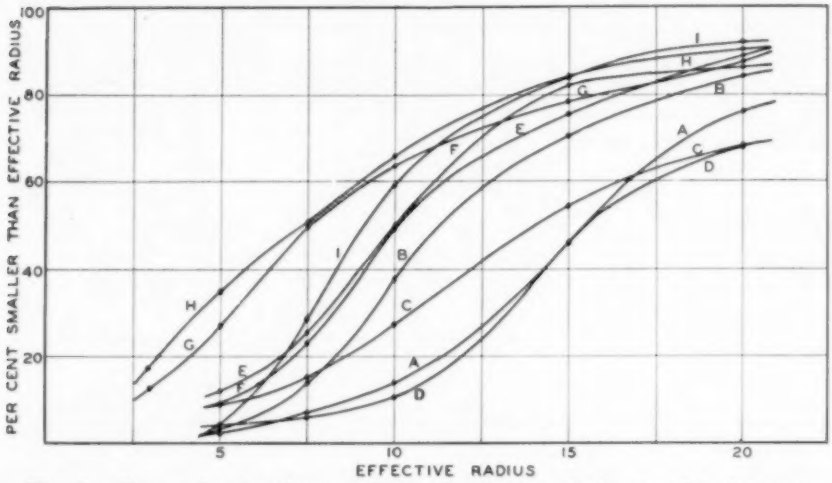

Fig. 2.—Curves showing the particle-size distribution of nine samples of commercial Paris greens. Effective radius in microns.

Discussion.—The results given in table 1 have been plotted in fig. 2 as cumulative frequency curves. This method of presenting the data gives a ready means of comparing the fineness of the samples. The highest curve indicates the finest material. The fact that nearly perfect sigmoid curves were obtained indicates that the particle-size distribution follows the law of probability. This type of distribution is probably quite general unless some fraction has been removed, but usually the range covered by sedimentation analysis is not sufficiently great to give a complete picture of the distribution.

The correlation of particle size with bulking value, as pointed out above, is very good, but the relation between density and particle size which occurs with calcium arsenate does not exist here. The two finest samples, G and H, have the greatest density, but the next in line, sample D, is one of the coarsest. There is also no apparent correlation between angle of slope and any of the other properties reported here. The air-floated sample H gives a very high angle, which is probably due to the decreased particle size. Since Paris green is a definite compound, copper

acetoarsenite, no change in the chemical properties is to be expected as the physical properties are varied.

The physical properties of an insecticide, especially the particle size, are very important. The coverage, the adherency and the efficiency of an insecticide in general are closely related to the particle size. More data on this subject are desired, especially in relation to laboratory and field tests on insects.

Summary.—The particle-size distribution of nine commercial samples of Paris green has been determined by sedimentation analysis. Except for one air-floated sample, the Paris greens were found to be coarser than the samples of calcium arsenate studied in a previous investigation. The particle form is indicated in photomicrographs, which also gave a check on the particle size as determined by sedimentation analysis. The loose bulking values were in approximately the same order as the results by sedimentation and may be used as a rough measure of the fineness of Paris green. The angle of slope indicates that in general Paris green will flow easily and dust well. The density of each sample was determined to check the purity of the samples and to obtain some idea of the uniformity of the different brands. Little variation in density was noted.—8-6-37.

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Housefly Age as a Factor in Susceptibility to Pyrethrum Sprays

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The Peet-Grady method has been in use for several years as the official method (Peet 1932, Simanton 1937) of the National Association of Insecticide and Disinfectant Manufacturers for evaluating household insecticides. This procedure specifies that flies, *Musca domestica* L., employed in testing shall be five days old. The literature on the subject of fly age does not disclose figures to show actual differences in susceptibility or in uniformity of flies subjected to test at specified

[1] Early publication of this paper has been secured by payment of the printing charge.

periods after emergence. Grady (1928) stated that his observations disclosed the adult housefly to be very active and resistant until about the eighth day after it emerged, reaching its peak of activity and resistance about the fifth day. In another paper, Peet & Grady (1928) pointed out the supposition that an old fly or a very young fly or a fly in any way enfeebled will be more susceptible to the action of any toxic material than will a strong, healthy individual.

Laboratories employing the Peet-Grady test for evaluating fly sprays have diverged somewhat from the original description of the test, in that they often use flies ranging in age from two to six days. In an attempt to

Table 1.—Susceptibility of flies of various ages to a pyrethrum fly spray as determined by the Peet-Grady method.

Age Group	No. Tests	No. Cages	No. Flies	Per Cent Males	Mean Per Cent Dead at 24 Hrs. Females	Mean Per Cent Dead at 24 Hrs. Males	Mean Per Cent Knockdown at 10 Min. Females	Mean Per Cent Knockdown at 10 Min. Males
1.5 hrs. ±.5 hr.	8	6	1535	48.5	2.1± .35*	2.3± .59*	99.1	98.5
6 hrs. ±2 hrs.	9	4	1529	43.7	12.7±1.75	11.6±1.14	98.1	99.2
21 hrs. ±2 hrs.	12	5	2239	56.7	36.3±2.49	62.7±4.27	96.3	98.9
45 hrs. ±2 hrs.	10	6	1654	60.4	40.2±6.	83.8±3.32	85.3	98.2
3 days ±4 hrs.	11	6	1762	50.3	41.8±3.88	91.5±2.09	95.5	98.5
4 days ±4 hrs.	13	7	1868	44.7	43.6±4.41	87. ±2.2	94.	98.8
5 days ±4 hrs.	11	6	1570	44.2	45.6±6.13	88. ±2.62	90.3	98.
7 days ±4 hrs.	11	6	1450	46.1	55.1±2.42	91.7±2.15	94.2	98.7
10 days ±4 hrs.	10	5	1626	24.6	52.2±1.98	95.4±1.71	98.5	100.

* Standard error.

show the extent to which fly age affects mortality, the writers conducted a series of tests in which a given insecticide was tested against flies of the same batch at specified intervals after emergence. Since Murray (1937) has shown that male flies differ widely from female flies in their susceptibility to pyrethrum household sprays, all flies in this series of tests were sexed, the mortalities for males and females being recorded separately.

To secure flies of the same age, four to six culture jars nearing the peak of emergence were entirely emptied of adults. All flies emerging within one hour thereafter were transferred to a stock cage and held for one hour before testing. When subjected to the insecticide, all flies used were then between one and two hours old. Flies emerging from these same cultures within four hours after the jars were first emptied were added to those flies taken off at the one-hour period, and these were held for four hours before testing. Thus all flies in the second age-group were from four to eight hours old. The cage, which received about 1200 flies from the four hours of emergence, was provided with milk for food and held for tests on older age groups. Whenever the flies in the cage attained a specified age, one to three lots of approximately 150 flies each were drawn off for testing.

From the description of the procedure as given above, it is obvious

that changes in susceptibility would be truly relative because flies from the same culture, emerging within a closely designated interval, were tested at several specified ages. It was not always possible to secure sufficient flies in the four-hour emergence period allowed, to enable tests to be made at each of the nine specified ages, but in the majority of cases at least five age groups were tested from each cage. Tests were repeated

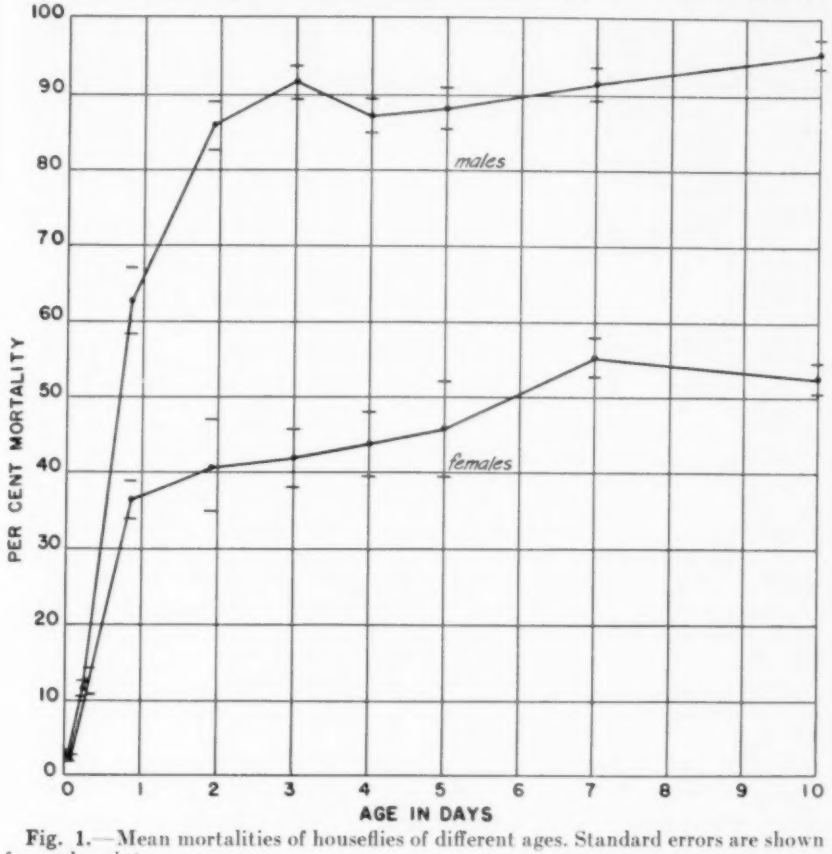

Fig. 1.—Mean mortalities of houseflies of different ages. Standard errors are shown for each point.

on different days with cages representing flies from several different cultures.

The insecticide used for all tests was made up of pyrethrum and a deodorized petroleum fly spray base, the finished spray containing 122 mg. of total pyrethrins per 100 ml. Such a spray would be considered a good quality household fly spray.

Tests were conducted by the Peet-Grady method (Peet 1932) plus the recent modification which calls for the use of absorbent paper on the chamber floor. The paper was discarded after one test on each side, and the chamber was thoroughly wiped and aired after each test.

Flies used in the investigation were reared on Richardson's culture medium, which consists of bran, alfalfa meal, malt, yeast and water. All flies appeared normal. Milk was placed in the cages for food eight hours after emergence and was replaced by fresh milk each day. Flies were not observed to take food until they were at least 12 hours old. The writers could observe no difference among the various age groups regarding activity of flies in the Peet-Grady Chamber immediately before spraying.

A total of 95 tests were made on 15,233 flies, the tests being divided among nine age groups. Table 1 gives a summary of the data obtained from the investigation. Figure 1 presents in graphic form the mortality data for each sex at the various ages.

When examining the data given in the table and in the graph, it should be remembered that the figures show the resistance of laboratory-reared flies. Judging from the short life cycle and the hardiness of the individuals, one can assume that houseflies reared in the laboratory are under nearly optimum conditions. In general, copulation begins on the second day, nearly all females being fertilized by the end of the third day. Oviposition usually begins on the third day, continues near the maximum through the ninth day, and then gradually diminishes.

It is interesting to note the association of mortality curve trends with reproductive activity. The standard errors shown for each point on the graph appear to indicate that variability in resistance to insecticides is the greatest during the ages at which copulation and oviposition occur. The graphic presentation of the standard errors also serves to show the validity of the trends in the male and female curves.

That very young flies should be much more resistant to an insecticide than older flies is quite unexpected. While the kill was much lower for the young flies, the speed of paralysis or speed of "knockdown" was much greater. At least 90 per cent of the one and one-half-hour and six-hour flies were completely paralyzed within one-half minute after spraying; whereas, with three or five-day old flies, 80 per cent were not knocked down until about two minutes after spraying, and even these were not completely paralyzed. The relationship of age to speed of paralysis could greatly affect results obtained from a testing procedure such as that described by Richardson (1931) which bases the toxicity of an insecticide on speed of paralysis.

The increasing difference in resistance of male and female flies between the six-hour and the 45-hour age groups is shown in the knockdown figures as well as in the kill figures. Considering only the three to five-day old flies, the ages commonly used in the Peet-Grady test, the mortalities show the females to be about twice as resistant as the males. Of the up flies, calculated from the knockdown data in table 1, there are about five times as many females as males.

A mortality curve for age groups having a 50:50 sex ratio would, of course, fall half way between the mortality curves for the males and females. Ordinarily, as shown in table 1, the sex ratio of flies liberated into the test chamber is quite variable. In a graph similar to fig. 1 but based on unsexed test units, the trends in the susceptibility of various age groups to the insecticide, excepting the two youngest age groups,

would be largely covered up due to the wide variation in mortality caused by the spread in sex ratio.

In addition to the age groups listed in table 1, five tests were made on 833 15-day old flies representing three different cultures. These tests gave a mean female kill of 53.6 per cent with a standard error of 2.7, and a male kill of 100 per cent. Mean knockdown figures were 100 per cent and 99.6 per cent respectively for males and females. Because most of the male flies die naturally between 10 and 15 days after emergence, the 15-hour age groups tested contained only a small percentage of male flies.

Summary.—An investigation was undertaken to determine the susceptibility of houseflies of various ages to a pyrethrum fly spray.

The data show that very young houseflies are more easily paralyzed but less easily killed than are older flies. By the Peet-Grady method females flies are about twice as difficult to kill as are male flies. Female flies are also more difficult to paralyze.

There are indications that both resistance and uniformity of resistance are closely associated with reproductive activity.—10-8-37.

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Tolerance of Animals to Pyrethrum Extracts

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The use of pyrethrum extract in light petroleum oil fractions as a control for the hibernating sugar beet leafhopper on winter range in California has led to the question of possible danger to grazing sheep and cattle on such treated land. Sprays are usually applied at the rate of 5 to 8 gallons of the undiluted oil-pyrethrum extract per acre, using either airplanes or ground power machines for applying. Under such methods of application, a considerable quantity of light oils, such as kerosene, is evaporated during application, thus reducing the amount of spray reaching range plants and also the pyrethrin content breaks down rapidly on exposure to air and sunlight, lowering its activity as an insecticide. Range spraying is done either when grazing animals are present at the time of application or more often when they are absent and are not given access to the sprayed vegetation until three or four days after the

application. No records being available as to the possible effect of such pyrethrum–petroleum-oil sprays on sheep and cattle, an extended series of experiments was made under range conditions and with grade sheep being prepared for market. More variation than was desirable was found in the test animals, as they included cross-breds of both the wool and mutton types, which interfered to a certain extent with uniform rates of gains. Otherwise all conditions of the entire feeding series were uniform and were also checked with feeding experiments of the same materials on rabbits.

Materials and methods.—The first experiments were made by spraying range type of feed, including natural wild grasses and a small amount of oak browse. The various spray materials, as will be indicated, were applied with a power sprayer in pens containing one-eighth to one-tenth of an acre. Fourteen lambs weighing 50 to 60 pounds were used in the first feeding series, three lambs being put in each of the corrals and two in the untreated check.

Table 1.—Specifications of oils used in sprays.

Temperature° F	Kerosene	Diesel Oil
Distillation History—Per Cent		
356	Initial	
394	10	
400		Initial
435	50	
456	70	
477		20
522	End Point	
530		50
670		90
740		End Point
Gravitation—° Baumé		
	41	27
Viscosity—Seconds		
	345*	40†
Unsulfonated Residue—Per Cent		
	93	50

* By Saybolt thermoviscosimeter.
† By Saybolt universal viscosimeter at 100° F.

Pen A was sprayed with a commercial leafhopper material made by extracting one-half pound of dry ground pyrethrum flowers, *Chrysanthemum cinerariaefolium*, in one gallon of kerosene. Pen B was sprayed with material made from a pyrethrum concentrate (20 pounds of pyrethrum flowers to 1 gallon of solvent) added to 39 gallons of Diesel oil. Diesel oil is an unrefined fraction commonly used as fuel oil, with a distillation range extending from a portion of the kerosene fraction over into the lightest form of lubricating oil. The oil, being unrefined, usually contains 1 to 1.25 per cent sulfur as well as various unsaturated hydrocarbons and olefins, giving it a characteristic odor. Pen C was sprayed with a laboratory-prepared material consisting of one-half pound of dried ground pyrethrum flowers extracted with 1 gallon of kerosene, and the extract mixed with 1 gallon of Diesel oil. Pen D was divided into two parts, one-half being sprayed with the same formula as used in pen B, and the other half left unsprayed to determine which portion would be preferred by the sheep. Pen E was an untreated check in which no spray of any kind was used.

Tests with sheep.—Before the sheep were turned into the pens, the latter were sprayed with the materials indicated at the rate of about 7 gallons per acre and the sheep turned in three days after the spray application. No additional feed of any kind was given to any pen for a few days so that any effects of the spray might be developed. Since no effects were noted following three weeks of grazing in these pens, regular feeding was then begun, using alfalfa hay in an amount that would be cleaned up readily and a small amount of rolled barley. The first feeding of grain was at the rate of one-quarter pound per head per day. This

was gradually increased over a period of 19 days up to three-quarters of a pound of grain per head a day, which is a light feed for fattening lambs. During the time of feeding, which covered 48 days, a total of 3½ tons of hay were fed, averaging 7.6 pounds per head a day, and a total of 512 pounds of barley. The hay was spread in a thin layer and thoroughly sprayed with the materials indicated for each pen. Following the spray application, the hay was loosely piled for 48 hours to insure thorough in-

Fig. 1.—Pen D of experimental field, showing sheep grazing in sprayed half.

corporation. Evaporation was reduced to a minimum during spraying by the use of a hand sprayer held as close as possible to the hay during the application. The pyrethrum extract would be affected but slightly as only the outside of the pile was exposed. No other feed was available in any of the pens during the time of feeding except the barley which, as has been indicated, amounted at the most to but three-quarters of a pound per day in contrast with 7.6 pounds of hay consumed daily. The amount of spray applied to the hay was made as nearly comparable as possible to the heavy spraying on the range and amounted to approximately 10 gallons per acre, so that in the entire time of feeding each sheep consumed at the very least 50 times as much of the sprayed material as could possibly be consumed by a flock feeding over a sprayed area. It should also be noted that animals feeding on the range would have opportunity of taking other feeds than the sprayed portions, while the confined animals had no such choice except in pen D. A decided prefer-

ence for the sprayed portion was noted in this pen as shown by the browse. The leaves from the oak sprouts in the sprayed half of the pen were completely eaten as high as the sheep could reach before feeding started on the unsprayed portion. Water and salt were before the animals at all times and care was taken to keep them in as contented condition as possible.

Feeding was concluded November 4, 1933. The average gains in the different pens and the check are shown in table 2. Comparison of the

Table 2.—Sheep feeding chart, showing weights of animals.

Pen No.	No. Sheep	Weight, Pounds					Gain	Av. Gain
		Sept. 17	Sept. 24	Sept. 30	Oct. 14	Nov. 3		
				Commercial Leafhopper Spray				
A	1	62.75	62.75	66.5	66.25	72.	9.25	
A	3	59.25	61.5	61.5	61.75	64.	4.75	6.8
A	10	58.5	58.5	58.5	61.	65.	6.5	
				Commercial Pyrethrum Extract in Diesel Oil				
B	6	51.	54.	55.	55.75	57.5	6.5	
B	14	70.75	72.	73.	73.50	72.	2.25	10.1
B	4	55.75	60.	63.50	66.75	69.5	13.25	
				Laboratory Extract of Pyrethrum Spray, One-half Pound Pyrethrum to 1 Gallon Diesel Oil				
C	5	55.75	59.5	60.	62.	63.	7.25	
C	12	50.	54.	58.	60.	60.5	10.5	9.3
C	13	73.25	79.	79.50	83.25	83.5	10.25	
				Choice of Feed Unsprayed or Sprayed as in Pens B				
D	8	51.25	58.	59	60.	63.5	12.25	
D	2	74.75	75.25	80.25	81.75	85.5	10.75	12.6
D	9	61.75	62*	61.75	65.75	76.5	14.75	
				Check—Unsprayed				
E	11	55.75	55.*	58.	61.	65.50	9.75	10.8
E	7	60.	60.	66.	70.50	72.	12.	

* Escaped and grazed outside of pens.

averages shows pen D sheep almost 2 pounds heavier than those in the check pen, while the sheep in pen B almost paralleled those in the check pen and those in pens A and C were slightly below. Such variances might be expected in any group of animals under such feeding tests and would indicate no particular difference between any of the plots under experiment. The preference for the sprayed portion of the pens, shown by the sheep in pen D, has also been noted in range work and may possibly be accounted for by the slight deposit of sulfur from the oil used, which contained more than 1 per cent of sulfur and also a very slight amount of saline matter.

Tests with rabbits.—A similar feeding test to that with sheep was made with rabbits which, on account of more rapid gains, show greater differences in weights than were found with sheep. Disease among rabbits interfered with the first part of the feeding, after which they were culled and a second experiment started on October 1 and continued until November 8, 1933. At this time it will be noted that the gains shown for the four pens fed with sprayed feed were almost identical with that of cage E where untreated feed was fed entirely.

Tests with ewes.—Since the first feeding experiments on lambs a few months old were conducted, it was realized that these were not comparable to range conditions. On the range, pregnant ewes may feed on

Table 3.—Rabbit feeding chart, showing weights of animals.

Cage No.	Rabbit No.	Weight—Pounds Oct. 1	Oct. 14	Nov. 8	Dec. 2	Gain
		Commercial Leafhopper Spray				
A	1	3.3	4.	5.	5.5	2.2
A	2	3.8	4.3	5.	5.5	1.7
		Commercial Pyrethrum Extract in Diesel Oil				
B	1	3.7	4.3	5.5	6.	1.3
B	2	4.	4.7	6.	6.5	2.5
		Oil and Pyrethrum				
C	1	3.7	4.2	5.7	6.	1.3
C	2	3.4	4.	5.3	5.5	2.1
		Choice of Feed Unsprayed or Sprayed as in Pen B				
D	1	3.3	3.9	5.2	5.5	2.2
D	2	3.5	4.3	6.	6.	2.5
		Check—Unsprayed				
E	1	3.8	4.2	5.7	5.5	1.7

sprayed plants to such an extent as to injure the lamb crop if the spray is detrimental. For the sake of a more exact comparison a second experiment was run, using four two-year old ewes to a pen and the same num-

Table 4.—Lamb feeding chart, showing weights of animals.

Pen No.	Lamb No.	Sex	Birth Date	Birth Weight	30-Day Weight	Gain	Av. Gain
			Commercial Leafhopper Spray				
A	5	F	2/ 1/34	11.	25.	14.	
A	6	F	2/ 1/34	8.5	14.75	6.25	
A	7	M	2/ 8/34	8.	18.	10.	10.5
A	8	F*	2/12/34	5.25	12.5	7.25	
A	9	M*	2/12/34	7.25	11.75	4.5	
			Commercial Pyrethrum Extract in Diesel Oil				
B	10	F	1/28/34	8.75	15.5	6.75	
B	11	F	2/ 1/34	7.25	16.25	9.	11.
B	12	M	2/13/34	9.5	25.25	15.75	
B	13	M	2/17/34	9.	21.5	12.5	
			Oil and Pyrethrum				
C	1	M	1/25/34	7.	19.25	12.25	
C	2	F	1/27/34	10.	19.5	9.5	10.4
C	3	M	1/28/34	7.75	16.	8.25	
C	4	F	2/ 8/34	10.	21.5	11.5	
			Check—Unsprayed				
Check	16	M	2/10/34	10.	22.5	12.5	11.6
Check	17	M	2/10/34	10.	20.5	10.5	(Corrected
Check	18	F	2/12/34	9.5	18.5	9.	for three†
Check	19†	M	2/14/34	11.	25.5	14.5	10.6)

* Twins.
† Corrected weight in the check is allowable since lamb 19 was from a Hampshire ewe, as text explains.

ber of check ewes, the latter receiving untreated hay only. This experiment began December 9, 1933, and continued until March 19, 1934. The same materials and identical proportions were used as in the first experiment, the only change being that the choice pen D was

omitted. Also, no grain was fed during any of the experiment, the only feed being alfalfa and grain hay, with what little green feed was available. All lambs were born in a normal condition, one weak twin dying in pen A, while one ewe was found to be barren. A second pair of twins brought the total of lambs up to 19. Each lamb was weighed following birth and again at the end of 32 to 53 days, owing to the irregularity of birth dates, table 4. Average weights of the three fed pens, A, B and C, were respectively 10.5, 11 and 10.4 pounds, while the check was 11.6 pounds for four lambs, but as indicated, this should be corrected and the

Table 5.—Lamb feeding chart, showing weights of animals.

Pen No.	Lamb No.	Days in Experiment	Birth Weight	Final Weight	Gain	Daily Av. Gain	Av. Gain per Pen
			Oil and Pyrethrum				
C	1	53	7.*	30.	23.	.43	
C	2	51	10.	29.	19.	.37	.38
C	3	50	7.75	22.75	15.	.3	
C	4	39	10.	26.75	16.75	.43	
			Commercial Leafhopper Spray				
A	5	47	11.	36.	25.	.53	
A	6	47	8.5	21.5	13.5	.28	.402
A	7	39	8.	22.5	14.5	.37	
	8†		5.25	14.	8.75		
A	9†	35	7.25	13.75	6.5	.43	
			Commercial Pyrethrum Extract in Diesel Oil				
B	10	50	8.75	22.75	14.	.28	
B	11	47	7.25	23.	16.5	.34	.41
B	12	32	9.5	28.25	18.75	.59	
B	13	30	9.	21.5	12.5	.42	
			Check—Unsprayed				
Check	16	37	10.	24.75	14.75	.4	
Check	17	37	10.	22.75	12.75	.35	.402
Check	18	35	9.5	21.25	11.75	.34	
Check	19	33	11.	28.25	17.25	.52	

* Twin.
† Twins.

weights of lambs 16 to 18 inclusive considered since lamb 19 was from a Hampshire ewe, which is a larger breed with a record of bigger lambs than normally occur to the cross of Shropshire and Rambouillet used in the three fed pens. With this correction the check pen would average 10.6 pounds. In table 5 the average daily pen gain per lamb was: Pen C .38; pen A .402; pen B .41; check .402 pounds. This proves that all four pens, irrespective of the spraying used, are exactly comparable although the mother ewes had been fed 81 days on nothing but sprayed hay.

Discussion.—The data secured in these feeding experiments where very great excesses of spray were fed to the sheep in question proved conclusively the harmlessness of the mixture to feeding lambs, pregnant ewes and to the lambs born to same. Any spraying done on the range, which would be available to grazing stock, would necessarily be reduced in volume and toxicity by evaporation of the oil and the breaking down of the highly complex compound extracted from the pyrethrum flowers. In the feeding experiments there was no opportunity for the animals to secure feed other than that which had received a heavy dosage of exactly the same material as applied to the range and over a continuous period

of 48 to 81 days, thus increasing the amount of residual material consumed 50 to 100 times.

There was no tendency to repelling action shown, as was brought out distinctly in pen D of the feeding experiments, where choice was given of feeding on sprayed and unsprayed grass and browse. In this case preference was actually shown for the sprayed portion of the pen, corroborating results of similar observations reported in the field. These results are such as would be expected from the materials included, as the active principle extracted from the pyrethrum flower is repeatedly recommended for treating the edible portions of vegetables, *e.g.*, see Compton (1932), Stone & Wisecup (1931) and Skinner (1931).

The active principle of pyrethrum is known to break down on exposure, as is generally recognized by chemists familiar with insecticides, and in confirmation of this, experiments were run in the laboratory in which it was found that on exposure to sunshine and open air for five hours, only 32 per cent of the normal activity to insects remained. Ten-minute exposure to sun lamp resulted in a loss of 49 per cent, while exposure in a darkened room for seven hours resulted in the normal activity remaining at 95 per cent.

The oil used as a carrier has as a base the same qualities as those used in medicinal preparations commonly used as bowel lubricants and recommended freely by the medical profession. The slight amount of unsaturated hydrocarbons, sulfur or organic acids present would be practically harmless even if taken in considerable quantity, and since these latter are all largely volatile on exposure to atmospheric conditions, they would of necessity largely evaporate within a few hours following application. The only possible objection that can be brought against such oils is the slight odor which would be present for a few hours following application, but in these experiments it was found that this odor could not be detected on the day following the application.—12-18-36.

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Winter Mortality of Chinch Bugs in Iowa

G. C. Decker and Floyd Andre, *Iowa Agricultural Experiment Station*,[1] *Ames*

The chinch bug, *Blissus leucopterus* Say, is generally regarded as a species fully capable of withstanding the hazards of winter. There seems, however, to be little or no quantitative data to support or refute this belief. Most of the publications which mention winter mortality treat

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the subject with brief generalized statements; detailed observations and quantitative data on the subject are sadly wanting. Headlee & McColloch (1913) made mortality counts in various types of cover during the winters of 1910–11 and 1911–12 and presented their findings in two tables. They found that in these two years the mortality in different types of cover varied between 15.4 and 100 per cent and that during the winter of 1910–11 65 per cent of the bugs hibernating in clumps of bluestem perished.

The present paper reports the occurrence of extensive mortality in Iowa during the winter of 1934–35 and calls attention to certain meteorological conditions which seem to be closely associated with the mortality.

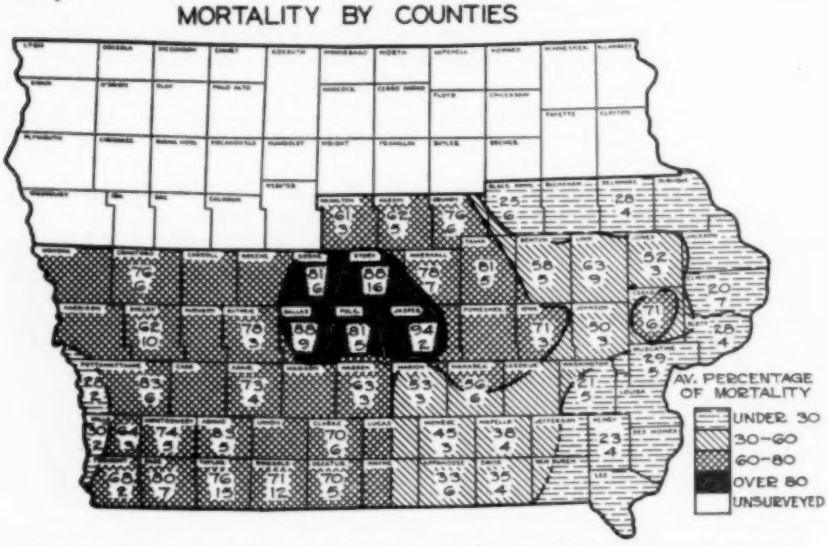

Fig. 1.—Winter mortality of chinch bugs in Iowa, 1934–35. Upper figures show average percentage of mortality; lower, number of samples averaged.

In March 1934 more than 100 samples of bunch grass and other types of cover were examined in the course of a spring population survey. Unfortunately, great care was not taken to count all the dead bugs; but it is doubtful that the winter mortality for that year exceeded 10 or 15 per cent.

On December 17, 1934, while collecting overwintering bugs for some laboratory studies, the writers found along a road near Des Moines many dead individuals among the bugs which were hibernating in a short thin turf of mixed grasses. Five samples of this turf which afforded the bugs very little insulation and which was devoid of snow cover on December 11, when the temperature dropped to −2° F, were taken to the laboratory for examination. It was found that 53, 68, 69, 74 and 81 per cent of the bugs in these five samples were dead, while the percentages of dead bugs in four good clumps of blue stem, *Andropogon furcatus* Muhl., taken nearby were 0, 1, 2 and 4 respectively.

Throughout the remainder of December and early January quantities of live bugs were collected from bluestem at frequent intervals but only slight attention was paid to the number of dead bugs, which remained comparatively low. On February 2 a number of clumps of bluestem which were brought into the laboratory yielded comparatively few live bugs; a count of the dead and live bugs in six clumps revealed mortalities of 78, 81, 87, 89, 94 and 97 per cent respectively. These results showed the need for investigations in other parts of the state. A hasty survey indicated an unusually high winter mortality over an extensive area. About March 1, when additional winter mortality seemed improbable, it was decided that samples from as many parts of the state as possible should be examined. Between March 1 and April 5, 253 samples of bunch grass, *Andropogon* spp., collected in 47 counties were examined for dead and living bugs. The average percentage of dead bugs and the number of samples taken in each county are shown on the map presented as fig. 1

Table 1.—Climatological data for Iowa. Averages of records from 106 stations.

Month	Temperature °F			Inches Precipitation			
	Mean for Month	62-Yr. Av.	Min. for Month	Total for Month	63-Yr. Av.	Snowfall Total for Month	Snowfall 43-Yr. Av.
December 1933	27.1	23.9	−30	1.05	1.19	2.8	5.7
January 1934	26.9	18.7	−14	.83	1.07	4.4	6.7
February 1934	25.	22.5	−25	.47	1.08	4.1	6.4
December 1934	21.5	23.9	−17	.57	1.19	5.5	5.7
January 1935	20.6	18.7	−30	1.16	1.07	2.9	6.7
February 1935	29.1	22.5	−19	1.13	1.08	5.5	6.4

The map shows that the greatest winter mortality occurred in the central and southwestern parts of the state and that the percentage of survivors was greatest in the southeast.

Meteorological data.—The winter of 1934–35 was generally mild and there were no extremely cold periods. The mean average temperature for December, January and February was 1.9° above the 62-year average and the precipitation for these three months was only .46 of an inch below the 62-year average, table 1. Average temperature for the three winter months was only 2.6° colder than the same three months of the preceding year (1933–34) and in both winters the minimum temperature recorded in the state was −30° F. Minimum temperatures recorded, and mean monthly temperatures, therefore, do not seem to be closely correlated with chinch bug winter mortality.

Laboratory studies of the effect of low temperatures on overwintering chinch bugs (Decker & Andre 1936) showed that the bugs are not particularly resistant to low temperatures.

The results of these investigations suggested that the insulation afforded by snow and debris in which the bugs hibernate protected them from exposure to extremely low temperatures.

Since frequent collections from the field showed that most of the bugs were killed between January 15 and February 2, the weather records for this period were studied closely to determine whether or not some specific condition might be associated with the high mortality observed. It was found that minimum temperatures varying between −8 and −23° F were recorded throughout the infested area. Since these temperatures

were not unusual for Iowa and since there seemed to be no relationship between the minimum temperature recorded and the percentage of mortality in any given county, it seemed apparent that low temperature alone was not responsible for the death of the insects.

The most extended cold wave and lowest temperature of the year occurred during the period under observation. Most of the stations reported subzero temperatures on four to six successive days. This condition, however, extended over all of the infested area and could not, therefore, account for the variations in the mortality occurring in the various counties.

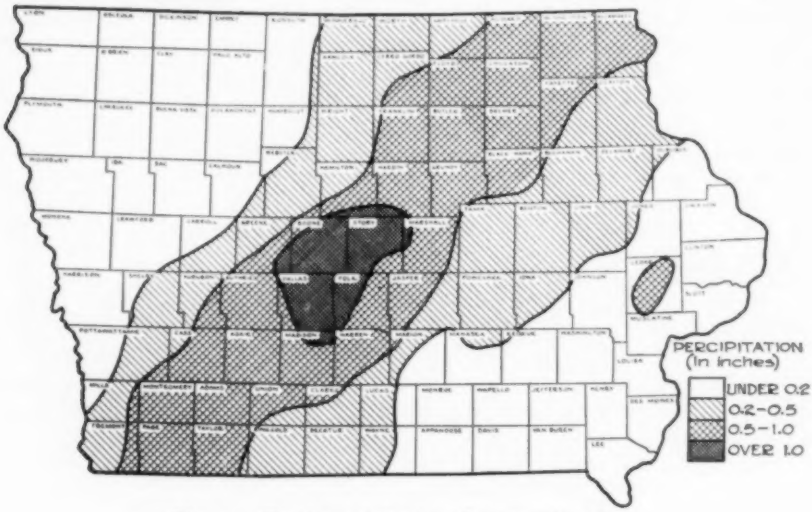

Fig. 2.—Total precipitation, January 19, 1935.

Precipitation for January was one of the factors which showed considerable variations; that is, the amount of rain and snow varied according to localities. A heavy rain and sleet storm, accompanied by thunder and lightning, passed over much of the area on January 19, and a rapid drop in temperature resulted in the formation of an extensive ice sheet over much of the state. When the precipitation for January 19, reported by the weather bureau stations throughout the state, was mapped, fig. 2, it was found that the area of greatest rainfall (more than 1 inch) coincided with the area of greatest mortality (more than 80 per cent). In Cedar county an isolated area of high precipitation (.6 inch) showed a mortality considerably higher than that in adjoining counties. In general all of the area which received more than .5 inch of rainfall during this storm showed a very high chinch bug mortality. In areas of lighter precipitation the relationship of the chinch bug mortality to precipitation was not so significant. This was undoubtedly partly because much of the moisture in these areas came in the form of snow and partly because the effect on the bugs was overshadowed by other factors.

Snow cover.—When the depth of accumulated snow on the ground

(January 19–25), as reported by the weather bureau stations, was mapped, fig. 3, and this map was compared with the one showing the insect mortality, the relationship existing between the snow cover and mortality became very evident. In the southwest quarter of the state, where the snow cover was practically negligible, the mortality was very high, whereas in the extreme east portion of the state where the snow ranged from 1 to 3 inches in depth (this implies drifts of greater depth in fence rows, hedges, etc.) the mortality was much lower. Between these two regions lay an area with intermediate snow cover where the mortality was moderate. The apparent influence of the snow cover is also shown

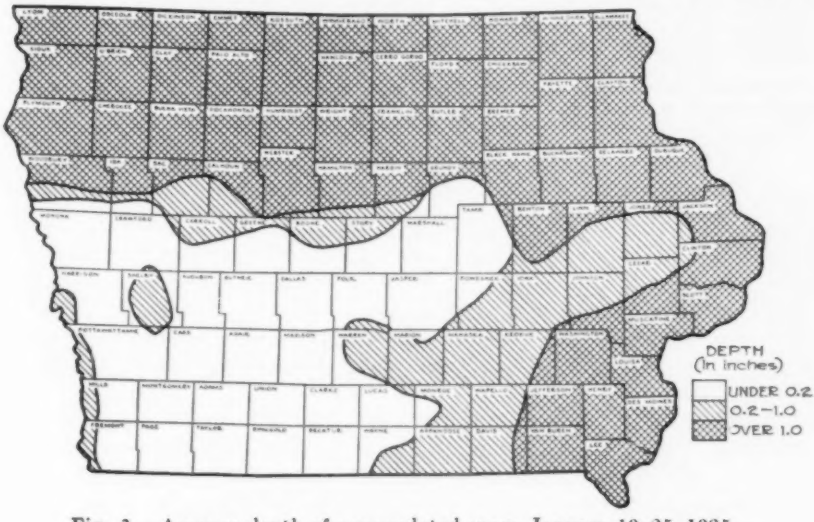

Fig. 3.—Average depth of accumulated snow, January 19–25, 1935.

in a number of isolated cases. In western Mills and Pottawattamie counties, where there was a moderate snow blanket, four samples of bunch grass revealed low mortalities which were completely out of line with the findings in other parts of the same counties. In Shelby county a small amount of snow was reflected in a slight reduction in mortality. In Benton county, where the snow cover was greater than in the counties on the east and on the west, the mortality was correspondingly lower; whereas, in nearby Grundy county the light snow cover was accompanied by a higher mortality.

The high mortality found in Marshall, Jasper, Tama, Poweshiek, Benton, Iowa, Linn, Johnson and Jones counties was not completely accounted for either in the absence of snow cover or in the rain storm of January 19. Another search of the weather records revealed that on January 16 a thunderstorm similar to that of January 19 had centered over this area.

Additional evidence that a good snow cover is an important factor in protecting overwintering bugs from exposure to low temperature was secured by determining in five counties the percentage of mortality of chinch bugs in clumps of blue stem with and without a snow cover,

table 2. In Clinton county, where there was a moderate blanket of snow during the cold wave, the average mortality was only 20 per cent; however, five clumps of grass in an exposed location, largely free of snow, yielded samples of chinch bugs which showed an average mortality of 88 per cent. In Story county the heavy rain (1.54 inch) greatly reduced the effect of the snow cover, probably by changing it to ice and thus reducing its insulating value.

It was observed that samples of grass from locations where hedges, shrubs, vine-covered fences or woods normally produce snow drifts nearly always produced more live bugs than similar samples taken in open or exposed situations. In many counties where the winter mortality was greatest it was found that the infestation in the small grain was largely confined to fields adjacent to hedges or timbered areas which

Table 2.—Influence of snow cover on winter mortality of chinch bugs overwintering in clumps of bluestem.

County	Good Snow Cover		No Snow Cover	
	No. Samples	Av. Mortality	No. Samples	Av. Mortality
Clinton	5	11	5	88
Polk	4	37	4	91
Story	3	51	5	92
Hardin	2	30	4	96
Linn	3	26	4	86

might be regarded as reflecting the effect of the accumulation of snow in such places.

Floods.—Observations on the possible effect of flood waters on overwintering bugs were very limited. In two instances live and dead bugs were found floating on the surface of back water which had covered an area known to contain many overwintering adults, but the ultimate fate of these bugs was not ascertained. On March 11 a quantity of corn stalks and other debris deposited in a fence row by flood waters was found literally "alive" with bugs. On March 28, as the flood waters of the Wapsipinicon river were receding, several clumps of bunch grass and two mullein plants, which were known to have been under water for more than two weeks, were examined and in all cases a large percentage of the bugs were alive.

Influence of types of cover on survival.—Because of the extreme drought of the summer of 1934 all types of vegetation made very poor growth and it is therefore probable that the insulating value of all types of winter cover was far below normal.

Within any given community the survival of bugs in bluestem and other bunch-forming grasses seemed to be in direct proportion to the density and quantity of cover. In many cases the bugs attempted to pass the winter in very sparse clumps where they were practically exposed to the elements. In such locations many of the bugs were killed by the first subzero weather early in December.

The mortality of bugs which hibernated in *Sporobolus* spp. was invariably greater than that in nearby clumps of *Andropogon* spp. This may have resulted from the habit of growth of the former, which forms

small compact clumps so dense at the crown that many of the bugs are suspended an inch or more above the ground surface, where they lose the benefit of the higher soil temperature. It is also possible that such clumps become dry and some mortality may have resulted from dehydration.

In the area where the rainfall of January 19 was heaviest and the resulting ice sheet was most extensive, the percentage of survivors seemed to be greatest in trash, under mullein plants and under leaves. It appeared that the penetration of the water into such cover was slight and as a result many air pockets remained. These samples seemed to indicate that bugs were better protected in dense blue grass or grass and

Table 3.—Temperatures recorded at the surface of the ground under various types of cover.

Date	Air Temp. °F	Types of Cover				
		Under 4 In. Snow	Matted Blue-grass	One-half In. of Trash	Bluestem Crown	Corn-stalks*
January 19	17.5	30.	27.	27.	32.	17.5
January 20	−4.	28.	16.	14.	27.	−4.
January 21	−8.	25.	14.	11.	23.	−8.
January 22	10.	21.	16.	14.	21.	10.
January 23	−15.	17.5	11.	10.	17.5	−13.
January 24	17.5	17.5	16.	16.	17.5	17.5
January 25	30.	21.	23.	23.	23.	30.

* Temperature between leaf sheath and main stalk of a standing corn plant.

leaves than they were in bunch grass, but since the miscellaneous samples were usually taken in fence rows, hedges or woodlands, it is probable that snow cover afforded them considerable increased protection.

All bugs observed which had attempted to hibernate in standing corn stalks and hollow weed stalks perished during the winter. However, a good many live bugs were found in corn shocks and a few were found in corn stalks and weed stems that had been covered with snow.

To obtain some idea of the insulating value of snow and grass, long-stemmed thermometers were placed at the ground surface under some of the various types of cover. The temperatures observed during the cold period of January 19 to 25 are given in table 3.

Conclusions.—During the winter of 1934–35, an unusually high winter mortality reduced the chinch bug population over a wide area in central and southwestern Iowa. Heavy rains immediately preceding the most severe cold wave of the winter and an absence of snow cover during this period appeared to have had an important influence on mortality. The reduced amount of insulation afforded by various types of cover was also an important factor.

The probability of a reoccurrence of such extensive winter mortality is a matter of speculation, and although the mortalities herein reported are (and probably should be) considered unusually large, it now seems possible if not probable that the average annual winter mortality of the chinch bug has been somewhat underestimated.—7-19-37.

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Method of Obtaining an Index to Density of Field Populations of Citrus Red Mite

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The citrus red mite, *Paratetranychus citri* McGregor, is one of the major pests of citrus throughout the greater portion of southern California, and is subject to wide and rapid fluctuations in population density. A field ecological study has been undertaken in an attempt to correlate these fluctuations with certain climatic factors and with the presence of arthropodan enemies. The work is restricted to a consideration of these species on lemon and orange trees.

The first consideration in the study was the development of an accurate method of measuring the density of mite populations. Methods based on estimation of populations were found to be unsatisfactory, since estimates of the numbers of mites and eggs on individual leaves, terminals or fruits were found to vary greatly from the numbers actually present. Counts of the populations present on unit areas of a given number of leaves or fruits proved equally unreliable for this species; such trials included the examination of halves of leaves, and counts made upon units of 1 and 2 square inches of plant surface. A prohibitively large amount of time would have been required to count all of the mites and eggs on a number of leaves and fruits sufficiently large to represent an adequate sample from a tree. It was necessary, therefore, to devise a less laborious and more accurate method of obtaining an index to the population densities of the mites.

The method which was developed and finally adopted involved the removal of the mites and eggs from a sample of leaves and fruits from a tree, and the counting of standardized portions of that population. Through the use of this method corresponding fractions of the populations of some of the predacious enemies of the mites could also be recorded.

Method of sampling individual trees.—The citrus red mite feeds upon both the upper and lower surfaces of the foliage and upon fruits. On lemon trees fruits are always available, and are sometimes present on orange trees throughout the year. In this particular study both leaves

[1] It is not intended that the authors be considered as junior and senior in the conventional sense; the work was jointly planned and performed. Many suggestions were given by Professor Harry S. Smith and Dr. A. M. Boyce, under whose direction the study was conducted.

and infested fruits, when the latter could be obtained, were included in the sample. Separate counts were made of the populations present on the north and south sides of trees to distinguish the possible differences in conditions influencing the development of mites during different seasons of the year.

After numerous trials 50 leaves and three fruits were found to constitute an adequate sample from one side of a tree. From trees on which fruits were not available or not infested, samples consisting only of leaves were equally satisfactory. For the purpose of sampling, a tree was considered to represent a cylinder. The sample from one side was chosen

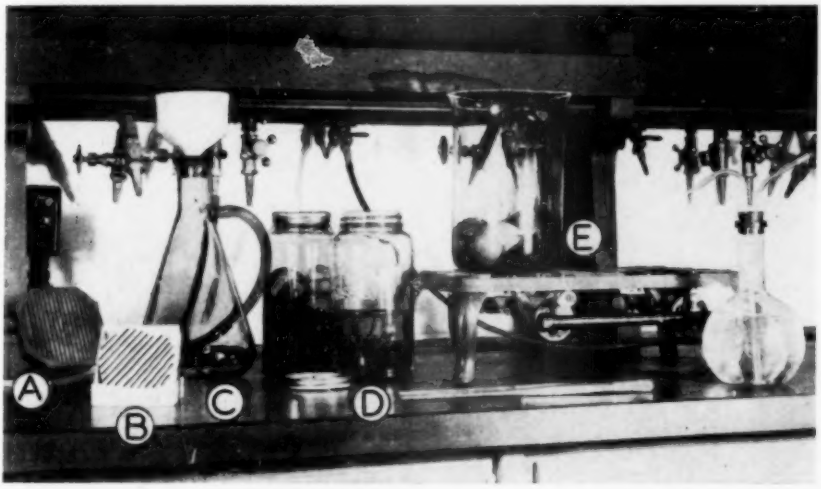

Fig. 1.—Equipment used in handling samples. *A*, rubber stamp for marking guide lines on filter papers; *B*, marked filter papers; *C*, Beuchner funnel and flask; *D*, sample jars; *E*, beaker containing leaves and fruits of a sample and potassium hydroxide solution.

from that region represented by one-half of the cylinder when cut vertically through the longitudinal axis. The leaves were picked at random from 1 to 6 feet above the ground, and an attempt was made to collect leaves in the same proportions from different parts of the specified region. When present, the three fruits from one-half of a tree were taken from near the periphery at fairly definite compass points. On a north half these would be northwest, north and northeast. Each fruit selected was the one which, after brief examination, appeared to be the most heavily infested at that station. Thus the leaves were collected at random, and the fruits selected on the basis of personal judgment. A random sample of fruits was not possible because of the comparatively small numbers present on the trees. Three fruits were therefore taken to represent the maximum number which could be taken from a tree at a given time. The leaves and fruits from one side of a tree were placed in a 2-quart, wide-mouthed Mason jar containing 800 cc. of a 5 per cent formalin solution, and were stored for as long a time as was desired before the mites were counted.

Method of counting samples.—In the laboratory the leaves and fruits of one sample were removed from the formalin solution by means of long-handled specimen forceps and placed in a 4000 cc. *Pyrex* beaker containing 800 cc. of a .25 per cent solution of potassium hydroxide heated to near the boiling point. This treatment was necessary to remove the eggs which are firmly attached to the plant surface. The hot solution of potassium hydroxide apparently does not noticeably damage the mites and eggs, which were washed from the leaves by gentle agitation. The leaves and fruits were kept in this solution for five minutes, during which time

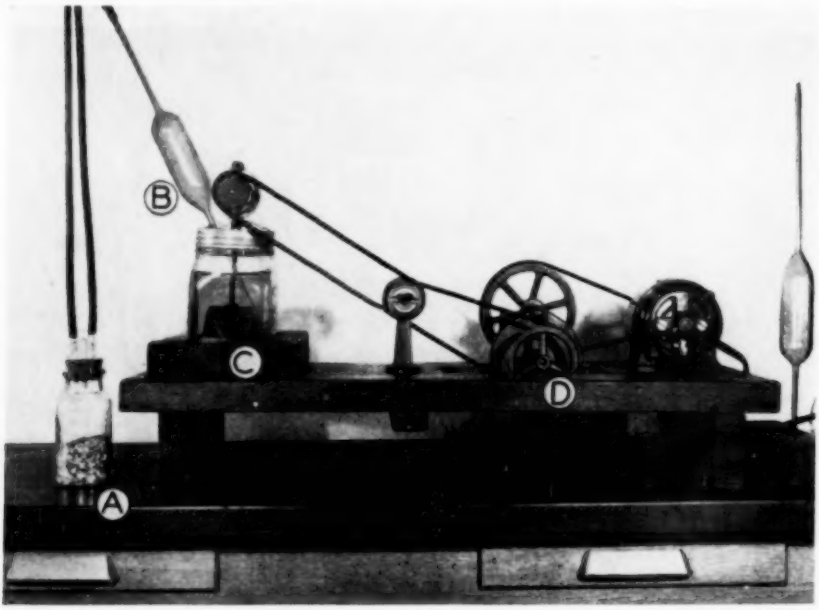

Fig. 2.—Apparatus for agitating fluid medium containing mites. *A*, assembly for regulating vacuum which filled pipette. Rubber tubing connects a vacuum line with the bottle; a second tube leads from the bottle to the pipette. Projecting from the bottom is a length of open glass tubing, the closing of which applies vacuum to the pipette. *B*, pipette. *C*, churn. *D*, reducing gears; gears of an emery wheel were utilized.

the mass was agitated frequently. Finally each individual leaf and fruit was raised slightly above the surface of the liquid and shaken vigorously to remove as much of the adhering fluid as possible, and then discarded, fig. 1.

After the removal of the plant material the potassium hydroxide solution and the formalin in the sample jar were poured into the 2-quart jar of a *Dazey* churn. Sufficient water was then added, if necessary, to bring the total volume to 1600 cc. The agitator assembly, equipped with a four-bladed paddle, was attached to the churn, which was placed in the apparatus illustrated in fig. 2. The motive power was supplied by a one-tenth h.p. electric motor connected by belt to reducing gears, which were in turn connected with the agitator pulley. Such a high-speed motor con-

nected with reducing gears was found necessary to reduce to a minimum the effect of fluctuations in electric energy. This apparatus when set into motion turned the agitator shaft in the churn at the constant rate of 150 r.p.m. Sufficient agitation was thus produced to maintain the mites and eggs in a relatively uniform suspension throughout the medium. After thorough agitation, and with the agitator turning, a 200 cc. aliquot was drawn from the mixture by means of a pipette connected with a vacuum line available in the laboratory. The aliquot, one-eighth of the whole, was filtered through a *Whatman No. 2* filter paper in a Beuchner funnel. The mites and eggs were deposited on the filter paper, which had previously been stamped with a series of parallel lines one-fourth inch apart by means of a rubber stamp and indelible ink. The filter paper was then placed on a damp paper towel to prevent desiccation, and the mites,

Table 1.—Total variation in numbers of individuals between the eight 200 cc. aliquots drawn from the same 1600 cc. sample.

Sample	No. Aliquots	Mites			Eggs			Total Mites and Eggs		
		Mean	Probable Error of Mean ± *	Probable Error in Per Cent of Mean†	Mean	Probable Error of Mean ± *	Probable Error in Per Cent of Mean†	Mean	Probable Error of Mean ± *	Probable Error in Per Cent of Mean†
1	8	70	1.71	2.45	103	3.36	3.27	173	4.4	2.54
2	8	68	2.45	3.51	134	1.75	1.3	202	2.02	1.
3	8	499	8.84	1.8	639	8.36	1.31	1138	4.33	.38
4	8	326	7.57	2.32	462	7.69	1.66	788	9.94	1.26
5	8	49	.9	1.83	80	1.88	2.35	129	2.01	1.55
6	8	21	.96	5.57	33	.73	2.2	53	1.05	1.96
7	8	22	.79	3.61	33	.99	3.01	55	1.6	2.9
8	8	36	.81	2.25	44	.66	1.52	80	.71	.89
Average of probable errors				*2.91*			*2.07*			*1.56*

* In each of these tests the number of aliquots taken was small so that the formula

$$P.E._m = \pm .6745\sqrt{\frac{\Sigma d^2}{n(n-1)}}$$

was used for the calculation of the probable errors of the means. (Where Σd^2 = the sum of the squares of the deviations of each count from the mean; n = number of counts; and m = the mean.)

† $\frac{P.E._m}{m} \times 100$.

eggs and arthropodan enemies present were counted with the aid of a low-power binocular microscope. The guide lines facilitated the counting of the mites on the paper. As the mites and eggs are unevenly distributed over the surface of the filter paper, the whole area must be examined to obtain accurate results, fig. 1.

Accuracy of method of counting samples.—In determining that the number of mites and eggs in a 200 cc. aliquot drawn from a 1600 cc. sample approximates one-eighth of the total population in that whole, the total agitated sample was drawn off in 200 cc. aliquots, and the various stages of mites in each were counted. This was repeated for eight different samples. The results are summarized in table 1.

The probable errors expressed in the per cent of the mean number of mites, of eggs, or of the total mites plus eggs of all the samples, each consisting of eight 200 cc. aliquots, range from 1 to 5.57 per cent with an average value of 1.56 per cent for the entire experiment. This value of 1.56 per cent is sufficiently small so that aliquots within samples may be considered homogeneous, that is, they probably vary no more than would

be expected in random sampling. Therefore within the limits of sampling variation a 200 cc. aliquot gives a reliable index to the total population of a sample. It may also be concluded from the variability of the data that the method and technique are adequate.

Accuracy of method of sampling trees.—Field samples consisting of 50 leaves and three fruits taken from both north and south sides of a tree appear to furnish a reliable index to the density of the mite population present on the tree. When the fruits are lacking or are not infested, the sample consisting of only 50 leaves also is satisfactory. The fact that by either method a single tree may be sampled two and four times with

Table 2.—Summary of tests of two methods of sampling trees, showing correspondence of samples taken from same trees. Four samples taken from one tree in each test.

Trial	Type Tree, Height	Mites			Eggs			Total Mites and Eggs		
		Mean	Probable Error of Mean±	Probable Error in Per Cent of Mean*	Mean	Probable Error of Mean±	Probable Error in Per Cent of Mean*	Mean	Probable Error of Mean±	Probable Error in Per Cent of Mean*
				Fifty Leaves Selected at Random						
1	Orange, 10 ft.	158	4.52	2.87	240	10.28	4.28	398	14.25	3.58
2	Orange, 10 ft.	48	4.75	9.96	90	4.47	5.32	138	8.86	6.42
3	Orange, 10 ft.	38	2.04	5.44	57	.87	1.53	95	2.82	2.98
4	Orange, 10 ft.	17	.8	4.78	29	.73	2.52	46	.58	1.27
5	Lemon, 20 ft.	204	5.1	2.5	267	8.15	3.05	471	12.23	2.6
6	Lemon, 20 ft.	150	5.29	3.54	187	5.	2.68	336	6.11	1.82
7	Lemon, 20 ft.	128	4.06	3.17	163	5.16	3.17	291	9.	3.1
Average of probable errors				*4.6*			*3.22*			*3.11*
				Fifty Leaves Selected at Random plus Three Most Heavily Infested Fruits						
1	Lemon, 12 ft.	76	2.29	3.01	198	5.14	2.6	274	4.47	1.63
2	Lemon, 12 ft.	49	2.1	4.29	189	12.21	6.48	238	13.96	5.88
3	Lemon, 12 ft.	66	5.97	9.05	164	8.03	4.91	230	12.46	5.43
4	Lemon, 12 ft.	44	2.18	5.01	162	5.32	3.28	206	7.29	3.55
5	Lemon, 12 ft.	41	2.99	7.29	133	7.94	5.96	174	10.75	6.17
Average of probable errors				*5.73*			*4.64*			*4.53*

* $\frac{P.E._m}{\overline{m}} \times 100.$

closely corresponding results suggests that both are valid. That this is possible was demonstrated by the series of trials, the results of which are summarized in tables 2 and 3.

In table 2 are tabulated the data which show the degree to which four samples taken from one tree correspond when collected according to one method. Four samples represent the maximum number which can be taken from a tree during trials of this kind without removing all the fruits with maximum infestations of mites.

Table 3 shows the correspondence of two samples from one tree. Statistical treatment of the data secured from these samples is probably of little value and therefore is not used.

One side of a tree was sampled in each test. This is logical, since one-half of a tree is the unit considered in the regular course of evaluating mite populations. The counts recorded in tables 2 and 3 were secured by counting one aliquot from each sample as previously described. As such they represent approximately one-eighth of the total populations of the samples and serve as indices to the populations present on the sides of the trees sampled.

The probable error of the mean number of either mites or eggs or the total mites and eggs in four samples from one side of a tree does not exceed 9.96 per cent of that mean. This suggests the possibility of using this type of sample to secure an index to population densities.

In this investigation, observations in each orchard were confined to a one-acre plot. Within the plot 10 trees in each of two series were selected. The trees of one series were selected to correspond in size and type and in the density of mite populations present to those of the other series.

Table 3.—Summary of two methods of sampling trees, showing correspondence of samples taken from same trees. Two samples taken from one tree in each test.

Trial	Type of Tree and Height	Population in Each Sample		
		Mites	Eggs	Total
	Fifty Leaves Selected at Random			
1	Lemon, 20 ft.	505	639	1144
		548	855	1403
2	Lemon, 20 ft.	364	420	784
		347	448	795
3	Orange, 10 ft.	72	131	203
		67	106	173
	Fifty Leaves Selected at Random plus Three Most Heavily Infested Fruits			
1	Lemon, 12 ft.	162	530	692
		164	541	705
2	Lemon, 12 ft.	257	380	637
		289	393	682
3	Lemon, 12 ft.	128	461	589
		112	437	549
4	Lemon, 12 ft.	190	164	354
		237	177	414
5	Lemon, 12 ft.	113	202	315
		137	168	305

Samples were taken from the 10 trees of one series at two-week intervals; the two series were sampled alternately. Thus, none of the trees were disturbed oftener than once in four weeks.

Method of obtaining indices to densities of populations of arthropodan enemies.—An evaluation of the population densities of the species of arachnids and insects predacious upon the red mite was an important aspect of this work. Records of the numbers of these which were associated with the red mites on the leaves and fruits collected as samples were obtained in the same manner as for the hosts. The larvae, nymphs and adults of the smaller predacious mites, together with the eggs, larvae and occasional adults of the insect enemies, were deposited on the filter papers and readily counted.

The adult insect predators which were capable of rapid movement were not adequately evaluated by such counts; nor was it possible to

secure reliable records of any stage of a species when but a few individuals were present. Therefore, supplementary records of natural enemies on the sampled trees were made by the use of an especially designed beating cage. The cage was box-shaped and measured 21×17×17 inches. It was constructed with a frame of three-fourths inch duraluminum tubing and covered, except for one end, with white muslin cloth. With the cage held in one hand, as many terminals or branches as would enter the 17-inch square opening were thrust into it and shaken. Most of the predators on the enclosed branches fell to the bottom of the cage or against its sides. After the cage had been removed from the terminals the enemies were classified and counted; the larger predacious mites, adult insects and some insect larvae were readily discernible against the white sides and bottom. After each sample was taken the predators were shaken out of the cage, or if they clung to its sides they were picked up in capsules. An effort was made to return these to the tree from which they were removed. Three separate samples of this kind were made on both the north and south halves of each tree. The cage was used after the leaf and fruit sample had been collected.

Summary.—An accurate and relatively rapid method of obtaining an index to populations of the citrus red mite, *Paratetranychus citri* McG., on citrus trees is practicable. This method involves the random collection of 50 leaves from each half of a tree and, when present, the selection of three heavily infested fruits from three relatively constant positions. The samples are placed in a 5 per cent formalin solution immediately after picking.

The samples are brought into the laboratory where the eggs are removed from the leaves by a hot solution of potassium hydroxide, and the solutions containing the mites and eggs combined in a *Dazey* churn. During uniform agitation a 200 cc. aliquot is removed and filtered. The mites and eggs thus secured, which represent one-eighth of the total mites and eggs present in the sample, are then counted with a low-power microscope.—5-24-37.

Flight Range and Longevity of Flood-water Mosquitoes in the Lower Columbia River Valley

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The distance over which mosquitoes will fly and the length of their life span both have an important bearing on their control. It has been reasonably well established that certain species travel as far as 60 or 70 miles and that other species remain within a few hundred yards, or even a few hundred feet, of where they emerged from their aquatic life. In the course of research on the biology and control of the flood-water mosquitoes *Aedes vexans* Meig. and *A. aldrichi* Dyar & Knab in the

lower Columbia river valley, the writers have collected considerable data regarding their flight range and life span.

The breeding habits of these mosquitoes are such that it is a comparatively simple matter to determine when and where the seasonal brood may be expected. The eggs are deposited on the ground in the summer, where they remain until the floods of the following spring bring about hatching. The date of hatching can be predicted fairly reliably from daily weather reports, because it follows the flood crests by about a week or 10 days. The earliest date recorded for the spring flood crest is May 9, the latest July 4. The greatest recorded crest height is 33 feet, and the lowest 9.7 feet. As many as four definite crests have been recorded during a season. Each crest, of course, covers a different level and causes eggs

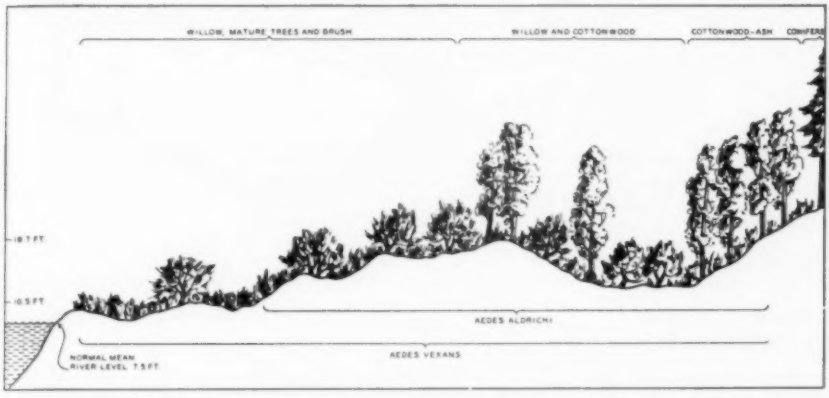

Fig. 1.—Diagram of composite profile of Columbia river bank from Hood river to the sea, showing relative altitudes of breeding grounds of the two flood-water mosquito species common in this locality.

deposited there to hatch, fig. 1. The swarms are large and usually occur in willow swales scattered through thousands of acres along the Columbia river from the Cascade mountains to the sea, a distance of some 140 miles. Mosquitoes of these species breed in similar situations along the Willamette river from Portland to the point of its union with the Columbia, near the mouths of several other tributaries to the Columbia, and on the islands in these rivers that are flooded by the annual freshets.

Flight range.—Since the breeding limits of *Aedes vexans* and *A. aldrichi* are fairly well defined in this locality, the minimum range, at least, of any adult found outside the breeding grounds can be determined. Sample collections and observations have been made over seven seasons, and definite data have been obtained by staining and recovering adults for five seasons.

The most satisfactory stain was a 1.5 per cent aqueous solution of methylene blue or eosine. It was applied with a hand compressed-air sprayer to newly emerged but hardened adults as they were resting in grass and nettles. As the operator walked through the vegetation, great swarms of the adults would slowly rise and many would receive droplets

of the stain. Of 1055 insects captured by two or three strokes of a sweeping net immediately after use of the sprayer, as high as 14.6 per cent had been stained. Hundreds of thousands must have been treated with each 20 gallons of spray, which was sufficient for about an acre of ground. Staining was done from the last of May to the middle of June, usually

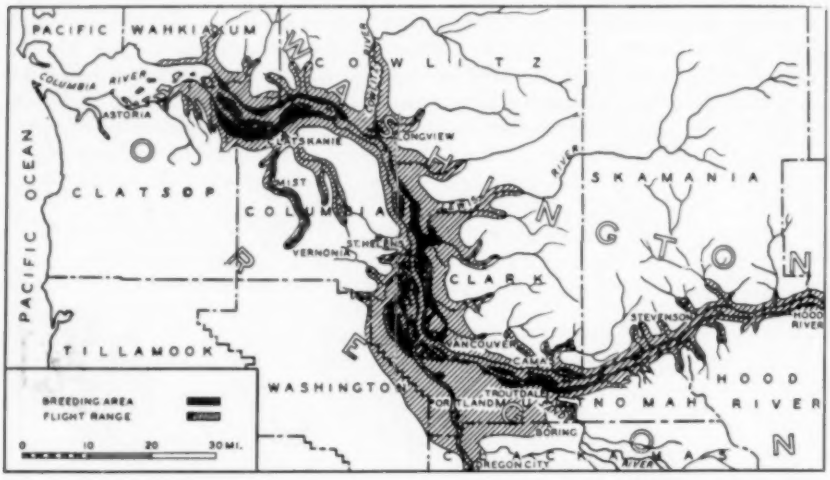

Fig. 2.—Breeding areas and approximate flight range of *Aedes aldrichi* and *A. vexans* in lower Columbia river valley.

several days after the passing of the annual flood crest of the Columbia river, on areas in Multnomah county, Ore., and in Clark county, Wash. Adults were collected throughout the treated areas at regular intervals thereafter until September or October, when no more could be found.

Table 1.—Number of adult flood-water mosquitoes captured, and number positive for stain.

Year	Adults Captured	Captured Adults Positive for Stain
1932	3,530	8
1933	3,583	6
1934	27,813	93
1935	5,746	102
1936	9,598	2
Total	*50,272*	*211*

Table 2.—Dates and heights of flood crests and greatest ages observed to be attained by flood-water mosquitoes.

Year	Date of Flood Crest	Height of Crest, Feet	Greatest Age Observed, Days
1930	June 15	11.1	112
1931	May 20	10.	107
1932	May 25	20.6	104
1933	June 13	24.8	85
1934	May 9	16.5	93
1935	June 11	17.2	102
1936	June 11	19.7	113

The adults were tested by killing them and treating each with one or two drops of a solvent made of 3 parts glycerin, 3 parts 95 per cent alcohol, and 1 part chloroform.

The number of adults captured and the number of captured adults showing traces of stain are shown in table 1.

From the individuals positive for stain the following facts were determined:

(1) Both species and both sexes were dispersed in all directions, both with and against general wind currents, for a distance of about 2 miles.

(2) Males moved away from the breeding areas more slowly than females.

(3) Females of both species traveled one-half mile across part of the Columbia river within 24 hours after being stained.

(4) Two *Aedes aldrichi* females crossed the Columbia river, Hayden island, and Oregon slough, a distance of about 3 miles, within 17 days.

(5) Six *Aedes aldrichi* females were taken nearly 5 miles from the point of staining, having crossed both the Columbia and the Willamette rivers.

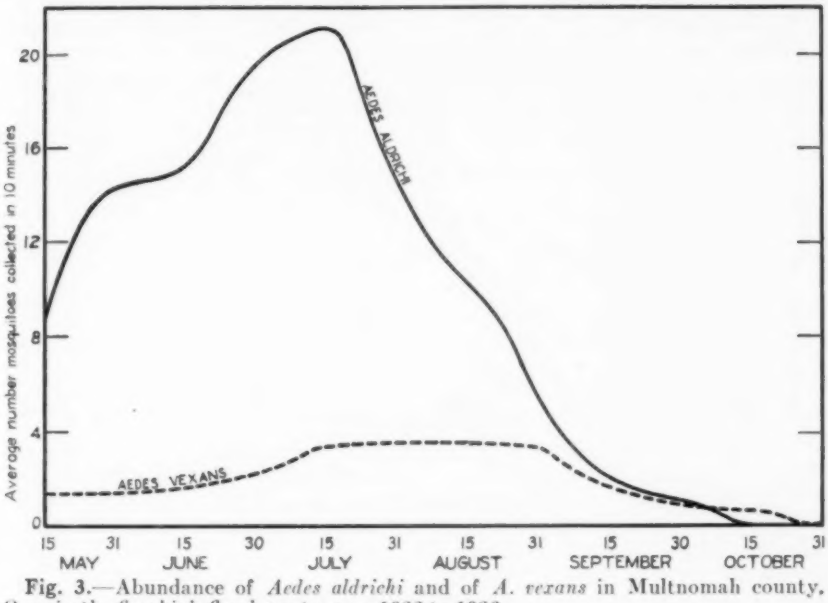

Fig. 3.—Abundance of *Aedes aldrichi* and of *A. vexans* in Multnomah county, Ore., in the five high-flood-crest years, 1932 to 1936.

(6) One *Aedes vexans* female was recovered 46 days after being stained, 3 miles distant and across the Columbia river.

(7) One *Aedes* sp. male was taken 24 days after being stained at a point 5 miles distant. This was the greatest distance for any positive flight record obtained.

Flight-range data obtained through staining tests were supplemented through collections and observations made at greater distances from the breeding grounds. For example, collections were made along a canyon road through a heavily timbered section south of Clatskanie, Ore., to a distance of 25 to 30 miles from the breeding grounds on the banks of the Columbia river. The pest was abundant to a distance of 15 miles from the breeding grounds, and then diminished rapidly until at about 30 miles a 10-minute collection yielded but one female. In the canyon of the Sandy river, near the mouth of which they breed in large numbers, these flood-water species constitute a real pest at a Y. M. C. A. camp 8

miles upstream. They have been taken in numbers at Boring, at least 10 miles from the nearest breeding area. At Wahkeena Falls, Ore., mosquitoes hatched on areas adjacent to the foot of the falls have been observed a few days later several hundred feet up the sides of an exceedingly steep canyon. The flight range as determined from these data is shown in fig. 2.

So far as the available data show, there is no great difference between the flight ranges of the two species discussed. As might have been expected, size of the brood directly influences the distance but not the rate of travel. Height of flood crest directly influences flight range, since the radius of dispersion is more or less proportional to the number of mosquitoes produced. In other words, the greater the flood the greater the radius of dispersion.

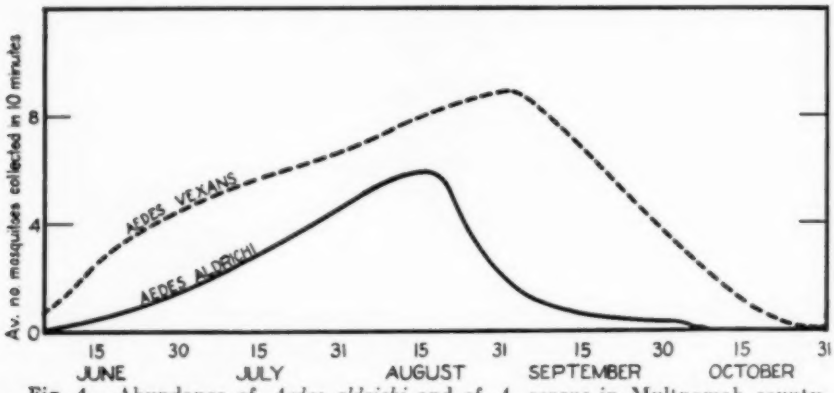

Fig. 4.—Abundance of *Aedes aldrichi* and of *A. vexans* in Multnomah county, Ore., in the low-flood-crest years, 1930 and 1931.

Longevity.—The staining tests produced the following data on longevity:

(1) Six *Aedes aldrichi* females were taken 52 days after being stained.
(2) One *Aedes* sp. male was taken 24 days after being stained.
(3) One *Aedes aldrichi* female was taken 85 days after being stained.
(4) One *Aedes vexans* female was taken 55 days after being stained.
(5) The average longevity of males is considerably less than that of females.

Since the beginning of the larval cycle of the two species under discussion corresponds closely with the dates of river floods, it was safe to use these dates as a basis for determining longevity. Emergence was assumed to be complete 10 days after the last crest of the annual freshet, and the period between that time and the time when the specimen was taken in the field was considered as the minimum duration of adult life. These data appear in table 2.

It appears that longevity may depend directly on the time of flood crest. There is no evidence, however, that the individuals hatched in May live longer than those hatched late in June.

Climate conditions in the breeding area probably exert the greatest

influence on life span. In the vicinity of Wahkeena Falls, for example, an *Aedes aldrichi* male 94 days old was found and females of both species were collected 104 to (rarely) 113 days after the final dates of emergence in middle and late June. These were the longest life spans recorded. Climatic and geographic factors in that vicinity were especially favorable. Mountains rising 3000 feet immediately on the south, the Columbia river and the high hills of its Washington shore on the north, and relatively narrow necks of land at the eastern and western extremities of the breeding area no doubt reduced the opportunities for dispersion and for long movements of flight. The temperature and humidity are also more favorable in this part of the Columbia gorge than in other parts of the district. Several waterfalls, considerable seepage and much water surface keep the humidity high, and since the area is protected by prominent points, its wind currents are gentle.

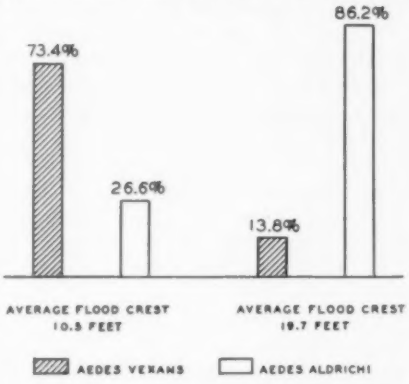

Fig. 5.—Relative abundance of *Aedes aldrichi* and of *A. vexans* in Multnomah county, Ore., in years of low and of high flood crest within the period 1930–36.

It should be mentioned that these long-lived individuals were taken in seasons of favorable weather during September and early October. After that, severe weather conditions always kill the remaining stragglers.

The available data on the abundance of the two species in Multnomah county, Ore., are given in figs. 3, 4 and 5. In 1930 and 1931, when the flood crest was low (averaging 10.5 feet), 73.4 per cent of the mosquitoes were *Aedes vexans* and 26.6 per cent were *A. aldrichi*, whereas in 1932 to 1936, inclusive, when the flood crest was high (averaging 19.7 feet), *A. aldrichi* constituted 86.2 per cent of the total number of mosquitoes collected and *A. vexans* 13.8 per cent. Evidently the greater number of *A. aldrichi* die late in July or in August, whereas the greater number of *A. vexans* survive until September. It appears also that *A. vexans* has the greater maximum longevity by approximately 15 to 20 days.—5-27-37.

Wintering Bees in Minnesota

M. C. TANQUARY, *Minnesota Agricultural Experiment Station*,[1] *St. Paul*

In all our nothern states beekeepers have long recognized wintering as one of their most serious problems. Reports from individual beekeepers of winter loss vary almost every year from nothing to 100 per cent loss, the average varying considerably with the year. It is true that many of the better beekeepers have developed methods of wintering

[1] Paper of the scientific journal series of the Minnesota Agricultural Experiment Station.

which have cut down their winter losses, and in some cases almost eliminated them, but the average annual loss is still very high, so high indeed that it is not uncommon to hear of beekeepers who kill all their bees at the end of each season and replace them each spring with package bees.

The methods of wintering used by different beekeepers vary considerably, and each variation has its advocates, who believe that by the use of their particular method a high degree of success may be expected and who can show by a record of successful wintering over a period of years good reason for their belief.

For a good many years the fundamental principles of bee behavior upon which any method of wintering must be based to be successful have been studied by federal and state experiment stations, and the results given to the public through bulletins and bee journals and by means of college teaching, short courses and extension work.

Table 1.—Results from questionnaire sent to 500 Minnesota beekeepers.

Method of Wintering	No. Beekeepers	No. Colonies	No. Colonies Lost	Per Cent Loss
Cellar only	42	5360	509	9.5
Outdoor only	26	2680	278	10.4
Cellar and outdoor	14	C. 2325 O. 1209	346 184	14.9 15.2
In shed	2	93	5	5.4
Killed out	3			

Packages Compared with Overwintered Colonies	
Reporting approximately equal in value	18
Reporting overwintered better	33
No report from the rest.	
Does it Pay to Kill Colonies in the Fall?	
Reporting yes	5
Reporting no	42
Undecided	11
No report from the rest.	

It seems desirable at this time to get some check on the extent to which this knowledge is being applied by the beekeepers and to learn of the success or failure of different methods as they are being used. To accomplish this a questionnaire was sent out in the spring of 1936 to about 500 beekeepers in Minnesota, asking, among other things, for information on: (1) number of colonies, (2) method of wintering, (3) dates of placing in cellar and of decellaring, (4) number of colonies packed outside, (5) arrangement of colonies and method of packing, (6) per cent of loss, (7) probable reason for loss, (8) preference between cellar wintering and outdoor wintering, (9) opinion as to desirability of killing out in fall, (10) comparison between package bees and overwintered colonies.

Some of the results of the questionnaire are summarized in table 1.

Of the 42 who winter in cellars, all prefer that method except one who prefers outdoor wintering and one who merely stated that he had had no experience in outdoor wintering.

Of the 26 who packed their bees outside, all prefer that method except two who would prefer cellars if good ones were available at the yards.

Of the 14 who wintered part of their colonies in the cellar and part out of doors, seven preferred the cellar and seven outside.

Both beekeepers who wintered in sheds prefer that method. One wintered 35 with a loss of three, and one 58 with a loss of two, all losses reported being due to starvation.

In answer to the question "Does it pay to kill the bees at the end of the honey flow?" five believe that it would, 14 think it would not, 11 are undecided, and the others gave no report.

As causes of death were given starvation, freezing, dysentery, queen-

lessness, poor quality stores, lack of adequate preparation of colonies in late summer, or a combination of two or more of the above factors.

The materials used for insulation include snow, wood cases, balsam wool, tar or asphalt paper alone, or in combination with one of the following: planer shavings, flax straw, grain straw, cellotex.

Some packed single colonies, some in twos, some in fours, and some in eights, the most common arrangement being in groups of two. Some reduced the colonies to one story, some to a story and a half, and some left two full stories. Some beekeepers used top entrances, some middle and some bottom entrances.

The following representative records and individual opinions as to the relative merits of cellar and outdoor wintering bring out the fact that under certain conditions one method of wintering is best while under other conditions another method is best, and emphasize the great need for a thorough understanding on the part of the beekeeper of all the many factors involved.

A wintered 52 colonies in the cellar with a loss of two. He writes, "Cellar wintering is more economical, more convenient and will prevent bees from flying when spring weather is unfit."

B wintered 243 outside. Six colonies died from starvation, five or six were weak in the spring and the rest extra strong. He writes, "Emphatically outdoor. Easier to handle in spring. Rear brood earlier and are much better strength."

C winter 585 outside with a loss of only 23 and states, "We prefer outdoor wintering as we find colonies come through stronger and more uniform in strength."

D has wintered 15 to 35 colonies in winter cases packed in leaves for the past seven years without the loss of a single colony. He gives as his preference "Outdoor—100 per cent."

E wintered 426 with a loss of only 18, packed outside, using tar paper and flax straw in two-story colonies and middle entrances. He states that the 18 that were lost were weak in the fall. His preference: "Outdoor, by all means. Less work. Better results."

F wintered 47 outside in one-story Jumbo hives, packed in pairs, with about 8 inches of grain straw all around and wrapped with asphalt paper; top entrance three-eighths by 1½ inches, covered with snow and good wind protection; lost only one colony, and that from starvation. He prefers outdoor wintering because of "Less heavy lifting, better cold protection in fall and spring, less winter losses, less attention needed to regulate temperature and moisture conditions, no fire insurance needed."

G wintered 400 outside packed in groups of eight in two-story or 1½ story 10-frame hives, using middle entrances, flax straw and asphalt paper and the group banked with earth, with a loss of only 10 by early May, and with about 91 per cent of the colonies coming through to the last of May as strong colonies. He says, "Here, we prefer outdoor wintering. If a good cellar were handy at yard, would prefer cellar wintering."

H wintered 350 in a cellar which is the basement of an old store building, with a loss of only five colonies. four being due to starvation. He kept a fire in a stove in this basement for more than 30 days. He prefers cellar wintering.

I wintered 650 in single-story colonies in cellars with a loss of 20, 10 of which were queenless in the fall. He prefers cellar wintering.

J, who wintered 220 with a loss of six, says "We prefer cellar wintering because it is more reliable under varying conditions."

K, who wintered 235 in the cellar with a loss of 20 from starvation and queenlessness, writes "Takes one day to cellar bees. To pack would take lots of time."

L, who wintered 80 in the cellar and 60 packed outside, without any loss by either method at the time of his report in April, prefers outside packing for outyards and is undecided for his home yard.

M wintered 40 in the cellar with a loss of six, and 141 outside with a loss of six. He prefers "Outdoor wintering, as they need no attention from the middle of October to the middle of May and winter stronger and build up faster and are more uniform in the spring."

It was interesting to note that most of the beekeepers who reported were able to determine the principal causes of most of their losses and to suggest the remedy. The winter of 1935–36 was an unusually severe one in Minnesota and gave a good test of any method of wintering. While the results as given are not of uniform value because of a difference in the times of reporting (some included spring dwindling as well as actual winter loss), and because of individual differences in accuracy of observing and reporting, it is believed that when sufficient data are gathered over a period of several seasons the results will be of value. The work will be continued to include the coming winter.—8-5-37.

Tracing Long-distance Movements of Beet Leafhopper in the Desert

H. E. Dorst and E. W. Davis,[1] *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*

Early in the study of beet leafhopper damage in Utah it became apparent that the injurious populations of the beet leafhopper, *Eutettix tenellus* (Baker), found in sugar-beet fields, had moved in from desert breeding areas. The desert areas that are of economic importance to the beet-growing region must be ascertained and delimited before any control of the leafhopper in the desert is possible. Thus, the tracing of leafhopper dispersals from breeding areas to sugar-beet regions is of primary importance in determining which areas are of economic significance.

Surveys have indicated that the movements of the beet leafhopper into the southern beet-growing section of Utah must be from a great distance. The nearest winter breeding area is about 200 miles southwest of the beet-growing region. A large portion of the territory over which these movements occur is desert. Climatic conditions in the fall are not suitable for the germination of annuals that will survive the winter and

[1] The writers express appreciation to Dr. P. N. Annand, formerly in charge of sugar-beet insect investigations, and to Dr. W. C. Cook, in charge, sugar-beet insect investigations, Bureau of Entomology and Plant Quarantine, for helpful suggestions in this work.

provide a good growth early in the spring. Consequently there is an absence of suitable plants upon which to detect leafhopper movement.

In order to have green annuals available upon the desert, small plots of host plants are germinated in the fall by irrigation and maintained in a growing condition so that early in the spring the plants are growing vigorously and are of a suitable size to be sampled for beet leafhopper populations. Two plants, *Cheirinia repanda* (L.) Link and *Sophia parviflora* (Lam.) Standl., were selected because each survives the winter and produces a rapid spring growth. Both of these plants are good hosts and because of their type of growth are excellent for the collection of insects by the net method.

Fig. 1.—A representative plot containing 100 square feet at Lynndyl, Utah, which shows the size of the plants at the time collections were begun.

Since the leafhopper travels with the wind, the plots were located with respect to exposure to prevailing winds. It was necessary to water the plants two or three times in the fall to obtain suitable plant growth. Each plot was in the vicinity of the residence of an individual trained in the method of collecting insects with the net.

In 1932, 14 plots of various sizes were planted, and each collector was instructed to take a daily collection of 100 sweeps with the insect net. It was found, however, that collections varied in proportion to the number of square feet of plants present. Because of this variation all plots in following seasons were made 100 square feet in size. Twenty-six plots were planted in 1933; 20 in 1934, and 19 in 1935. It was noticed that some of the collectors obtained a larger proportion of the insects present than others. The collectors were instructed to go over the plots as many times as necessary, and not less than three, to obtain all the *Eutettix tenellus*. Although the inefficiency of the net method was realized, this was the best that could be done. This procedure was performed during the warmest part of the day.

These collections were sent to the laboratory, where the specimens of *Eutettix tenellus* were determined under the binocular microscope and the number recorded.

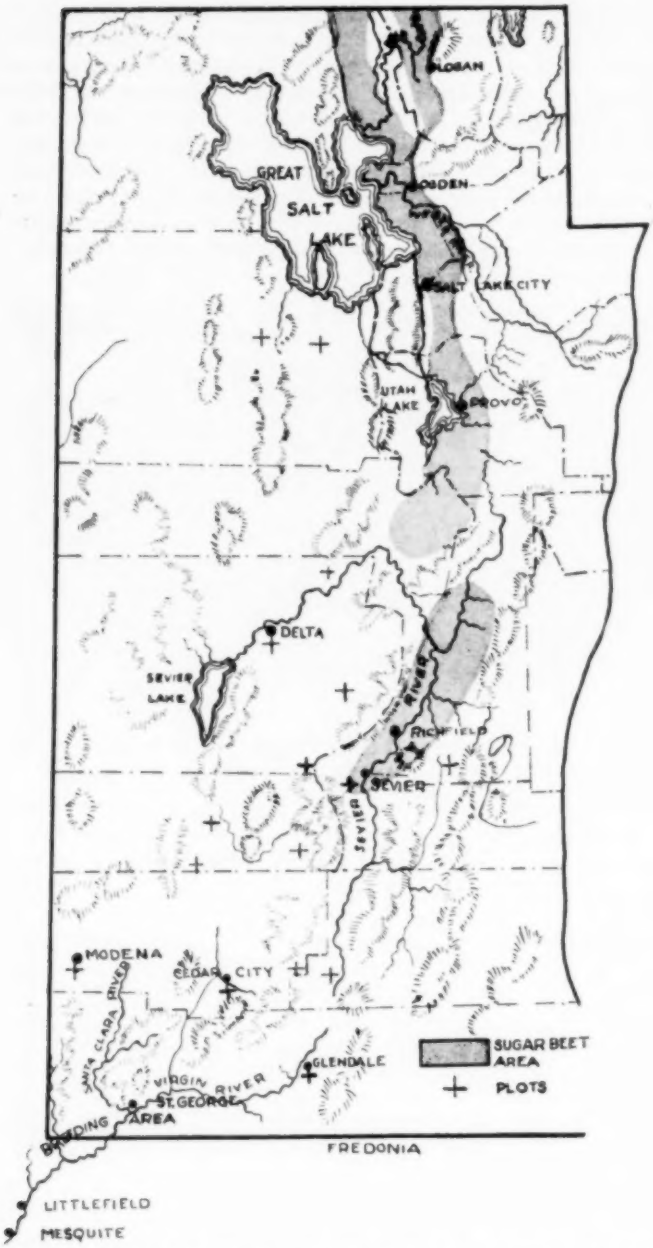

Fig. 2.—The western half of Utah, showing the relative locations of plots, beet-growing region and breeding area of the beet leafhoppers.

A representative plot, fig. 1, at Lynndyl, Utah, shows the size of plants at the time collections were being made.

In the map, fig. 2, are given the locations of the plots used in tracing the long-distance movement by this method. Although many other plots

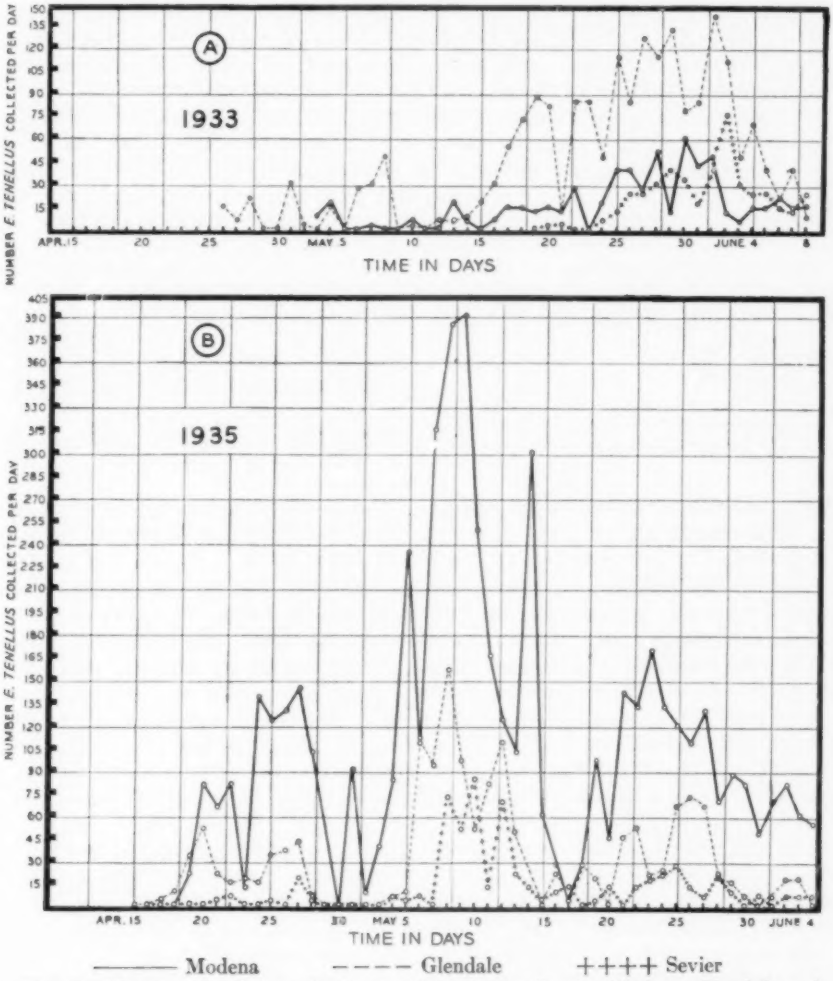

Fig. 3.—Chart of the daily collections of *Eutettix tenellus* for Modena, Glendale and Sevier, Utah, for 1933 and 1935.

were placed to the northwest, west and southwest to check other possible routes and sources, the results were negative. Only the positive results are here recorded. Most of the mountain ranges in this area run from north to south. The Virgin and Santa Clara rivers and their tributaries drain the breeding area of southern Utah, northwestern Arizona,

and a portion of southern Nevada. These rivers create openings through mountains and offer routes of dispersal for the beet leafhopper to follow. The plots were established near these openings from the winter breeding area and on routes that might be followed. One route follows the Santa Clara river, north through Modena and the Escalante desert. Another follows the Virgin river northeast through Glendale and down the Sevier river into the beet section of central Utah. Another route follows a tributary of the Virgin river north through Cedar City and enters the beet-growing section by way of the Sevier river and its tributaries.

The data obtained on the location and date of collection of the migrants of *E. tenellus* indicate the time when dispersal from the winter breeding grounds began and also the speed, and direction of the movement after dispersal got underway. The first migrants arrived at Sevier station (the southern end of the sugar-beet region) in 1932 on April 15; in

Table 1.—Peaks of dispersal of *Eutettix tenellus* in southern Utah, 1933–1935.

	1932	1933	1934	1935
Modena	May 30	June 1	May 4*	May 9
Glendale	June 1	May 30	May 7	May 8
Sevier	June 2	June 2	May 5	May 10

* In this year the Modena plot was destroyed; therefore, the peak collection at Nada, a nearby station, was substituted.

1933 the collections were not begun until after the movement had started in 1934 on March 18, and in 1935 on April 15. The peak of the dispersals was some time afterwards.

In fig. 3 are plotted the daily collections from three plots of 1933 and 1935. As it is not feasible to chart the collections from all the plots, these three have been chosen because of their location, although other stations along the routes substantiate the points discussed. All the specimens of *Eutettix tenellus* recorded from these and other stations were migratory bugs. Modena and Glendale are about 40 miles from the large winter breeding area and on two distinct routes of migration. Sevier station is near the sugar-beet region and at the junction of the Glendale and Modena routes. The Sevier station is approximately 150 miles from both of the other stations.

It will be observed in the graph that at all three stations for both years the number of *Eutettix tenellus* per collection increased in general until a peak was reached, and then they decreased. The collection curve for each individual station is very irregular because of the influence of variable climatic conditions at each plot at the time of the collection. The collections from the various stations showed the Glendale route to have been the most important in 1933, while in 1935 the Modena route was the most important.

Table 1 gives the peaks of dispersal at Modena, Glendale, and Sevier for the four years that the plot method has been used.

Glendale recorded the peak collection two days earlier than Modena in 1933 and one day earlier in 1935. In 1932 the peak collection was recorded at Modena two days earlier than at Glendale, while in 1934

the Modena[2] peak collection appeared three days earlier than that of Glendale. The peak collection at Sevier, which is near the beet section of central Utah, has been one to three days later than at Modena. With the exception of 1934, the peak collection at Glendale was reached one to three days earlier than at Sevier. The occurrences of the insects at these points in 1934 were probably affected by certain wind directions, as the other plots showed no indications that a separate source of infestation existed. With the exception of 1934, the peak collections indicate that the time necessary for the dispersal to travel from points near the winter breeding area to the beet-growing section of central Utah is about two days.

The time of the dispersal is fundamentally governed by the rate of maturity of the broods in the breeding area. Dispersal itself is influenced by the climatic conditions, especially wind and temperature encountered, which affect the direction and rate of travel of the leafhopper. On a given route, direction of dispersal can be determined by the inverse ratio of size of collections to distance from breeding area. Data from plots in 1933 showed that, even after dispersal had begun, adverse winds delayed its progress, after which the movement to the beet-growing region continued.

This method of tracing dispersals over desert areas devoid of suitable host plants, upon which movements could be detected, enables comparisons to be made of the date and magnitude of movement for different years.

Fulton & Chamberlin (1931) have described an automatic insect trap for the study of insect dispersion which is fundamentally an air filter containing a series of screens. The trap is so mounted that it always faces the direction from which the wind is blowing and retains the insects borne by a representative moving current of air. It has been used with apparent success in studies in Idaho. These traps have been used in Utah in an attempt to determine the source of long-distance movement of beet leafhoppers, but have not proved as satisfactory as the plot method.

The chief disadvantage of the plot method is that the plots are occasionally winter killed or destroyed by animals. It has the distinct advantage over the previously described trap by Fulton & Chamberlin (1931) in that the area exposed to beet leafhopper movement at each station is much larger. The first requisite of the plot method is that there shall be an absence of host plants of the insect desired except in the planted plots. Daily collections are large enough so that it is not necessary to resort to weekly averages to make comparisons. If weather conditions are such that collections cannot be made from plots, it is highly probable that these same conditions would not permit dispersal of leafhoppers.

This method has been found satisfactory in determining the general routes of dispersal of the beet leafhopper in long-distance movements in Utah, and may be applicable in tracing routes of other migratory insects in territory where natural host plants are not present.

Summary.—The method of tracing long-distance movements of the

[2] See footnote under table 1.

beet leafhopper, *Eutettix tenellus* (Baker), by the plot method provides for the establishment of small plots of host plants on the desert. The dispersal is over the desert in which these plots are located. The plants are irrigated in the fall and maintained in a growing condition so that early in the spring they are growing vigorously and are of suitable size to be sampled for migrating leafhoppers. The plots are located in the vicinity of some residence so that collections may be conveniently made each day. This method is applicable in tracing long-distance movements over deserts that naturally do not have host plants or other suitable plants on which dispersals could be detected. Four years' data obtained by this method verify earlier deductions that the spring movement of the beet leafhopper into the central Utah beet-growing section originates in the lower Virgin river basin.—4-19-37.

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Toxicity of High Temperatures to Bean Weevil Eggs

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The mortality curve obtained by allowing a toxic agent to act on a group of insects can be considered as the product of at least three factors. The three most important factors, or variables, are concentration of the toxic agent, duration of exposure of the insects to the toxic agent and the effects of the toxic agent on the insects. Therefore, we may have concentration-mortality, time-mortality or time-concentration curves for a given mortality, depending on which variable is held constant. The different types of curves obtained by the above methods usually show that insects vary greatly in their resistance to the toxic agent and the error in the determination is mainly due to this variability.

The present paper contains the results of a study of the hatching of eggs of bean weevil, *Bruchus obtectus* Say, after exposure for various periods to high temperatures. High temperature was selected as a toxic agent because of the ease with which it can be accurately measured and controlled.

Experimental methods.—The bean weevil eggs of known age obtained from cultures (Pyenson & Menusan 1937) maintained at a standard environment of 25° C and 70 per cent relative humidity, were subdivided into lots of 100 eggs each. The eggs were then placed in 25×150 mm. *Pyrex* test tubes and the tubes placed in a holder to facilitate immersion into a hot water bath with the temperature controlled within .02° C. When the time was varied and the temperature was held constant all test tubes were immersed 100 mm. into the bath simultaneously then re-

[1] The authors are indebted to Professors F. L. Campbell, H. H. Shepard and F. Z. Hartzell for their many helpful suggestions in revision of the manuscript.

moved at stated intervals. When the temperature was varied and the time held constant, each test tube was individually exposed to the given temperature. The bath temperature was rapidly changed by adding cold water in the series when the temperature was lowered or by adding hot water in the series when the temperature was raised. These series were alternated so that slight differences in the age of the eggs averaging one or two hours would not affect the results obtained at either end of the toxicity curve.

Short exposure periods were used in all the experiments to minimize the effects of the exposure on egg resistance and development. The short exposures also rendered it unnecessary to control the relative humidity which varied from 5 to 25 per cent during the exposures. After exposure the bean weevil eggs were replaced in the standard environment of 25° C and 70 per cent relative humidity and the percentage hatching determined for each lot. The eggs were examined daily since more frequent examinations did not appear to be necessary. Many eggs after treatment developed until the head capsule was clearly visible, then died; in a few cases the larvae developed within the egg but could not emerge. This failure to emerge might be considered as due to a hardening or some other physical change in the egg shell although it is more likely due to the general debility of the larvae. In this study all larvae that did not emerge were classified as dead.

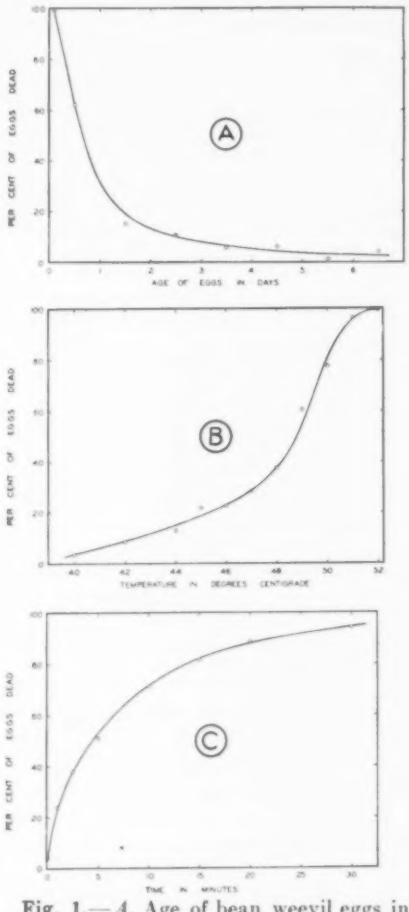

Fig. 1.—*A*, Age of bean weevil eggs in relation to mortality with exposure for 20 minutes at 48° C; *B*, mortality of bean weevil eggs 0 to 1 day old exposed for 10 minutes at various constant temperatures; *C*, mortality of bean weevil eggs 0 to 1 day old in relation to time of exposure at 50° C.

Experimental results.—Preliminary experiments indicated that the resistance of the bean weevil eggs to heat increased with the age of the eggs. When exposed to 48° C for 20 minutes, more than 99 per cent of two-hour old eggs died, while with eggs more than three days old only

about 4 per cent died. The results obtained, based on four replicate tests or a total of 400 eggs per point, are shown in fig. 1, *A*. These results are quite different from those reported by Pyenson & MacLeod (1936) for naphthalene fumigation of bean weevil eggs, although they agree with the results obtained by these investigators when using *Tenebrio molitor* L. eggs. The increased resistance with increased age of the eggs obtained by the author is no doubt due in part to an increase in the size and complexity of the organism with age. In all other experiments it was found to be most practical to use bean weevil eggs zero to one day old.

Table 1.—Mortality range and mean mortality of replicate tests with bean weevil eggs (0 to 1 day old) exposed for 10 minutes at various constant temperatures.

Temp. °C.	Total No. Eggs	Per Cent of Eggs Failing to Hatch			
		Minimum	Maximum	Mortality Range	Mean Mortality
40	1000	1	9	8	4.3± .98*
42	1000	3	15	12	8.5±1.24
44	1000	6	18	12	12.9±1.43
45	1000	12	27	15	21.5±1.62
46	1000	12	35	23	22.6±2.65
47	1000	13	44	31	28.2±3.07
48	1000	19	54	35	37.4±3.26
49	1000	48	76	28	60.6±3.38
50	1000	68	86	18	77.5±2.06
51	1000	91	98	7	96.4± .69
52	1000	99	100	1	99.9

* Standard error of the mean obtained by means of the formula $\sqrt{\frac{\Sigma d^2}{n(n-1)}}$.

A series of bean weevil eggs was exposed to temperatures ranging from 40° to 52° C while the time of exposure (10 minutes) was held constant. Since it was desired to determine toxicity with a high degree of accuracy, 10 separate determinations of the points necessary for a mortality curve were made. At 52° C, table 1, there was only one case in 10 trials where a 100 per cent mortality was not obtained, therefore since it is not known how often the minimum lethal dose was exceeded, the standard error of the mean was not calculated.

The results show that the greatest variation in replicate determinations of lethality was in the median range of the temperature mortality curve. This was indicated by the greatest difference between the maximum and minimum mortality obtained at individual temperatures, and more accurately shown by the standard error of each. The lack of symmetry in the temperature-mortality curve is shown in fig. 1, *B*.

For purposes of comparisons a time-mortality curve was determined in the manner described previously. With a 30-minute exposure at 50° C, table 2, the mortality was 100 per cent in one case out of 10. In this particular case two larvae completely developed within the egg shell but could not emerge although they remained alive for several days. The time-mortality curve, fig. 1, *C*, was different in shape from the tem-

perature-mortality curve, fig. 1, *B*, and the greatest variation in mortality determinations was in the median range.

Both of the curves, fig. 1, *B* and *C*, as determined experimentally are asymmetrical and in this respect differ from the usual toxicity curves which are assumed to be symmetrical. It is apparent that in these cases

Table 2.—Mortality range and mean mortality of replicate tests with bean weevil eggs (0 to 1 day old) exposed at 50° C for various periods.

Exposure Minutes	Total No. Eggs	Per Cent of Eggs Failing to Hatch			
		Minimum	Maximum	Mortality Range	Mean Mortality
0	1000	2	8	6	3.8± .59*
1	1000	16	32	16	23.9±1.47
2.5	1000	28	57	29	38. ±3.01
5	1000	32	72	40	51.2±3.86
10	1000	59	88	29	71.4±2.78
15	1000	68	97	29	81.9±3.02
20	1000	76	98	22	88.9±2.16
30	1000	89	100	11	94.6±1.51

* Standard error of the mean.

the variation in dosage (degree of temperature or length of exposure to a constant high temperature) of replicate determinations is least at the higher temperature in one case, fig. 1, *B*, and the shorter exposure periods in the other, fig. 1, *C*.

To test whether experiments conducted at the same time would give results similar to those obtained with tests replicated at intervals, one

Table 3.—Mean number of days required to complete incubation for bean weevil eggs which survived heat treatments when 0 to 1 day old.

No. Replicates	Total No. Eggs	Per Cent Mortality	Incubation Period, Days
20	2000	3 (controls)	6.51
10	1000	12	6.63
10	1000	16	6.65
30	3000	25	6.79
10	1000	31	6.95
20	2000	39	7.03
10	1000	51	7.15
10	1000	62	7.36
10	1000	71	7.56
10	1000	78	7.81
10	1000	82	7.91
10	1000	89	8.11
20	2000	96	8.31

experiment was conducted in triplicate. The time-mortality curve results obtained in this manner agreed with those obtained in the previous tests. In cases where the resistance of individual insects varied greatly between tests, replicate tests would not be comparable since a comparatively small change in natural mortality might indicate a tremendous shift in the resistance of the insects. With bean weevil eggs the natural mortality

in the controls approximated 3 per cent, varying from 0 to 8 per cent in different samples. This variation in natural mortality did not appear to indicate any great shift in the resistance of the eggs to high temperatures under the conditions of the experiments.

In the course of the experiments it was noticed that eggs surviving heat treatments which killed varying proportions of the population always required a longer period for incubation. The delay in hatching varied directly with the effectiveness of the heat treatment as measured by resultant mortality, table 3. Similar delays in hatching were reported with naphthalene fumigation of insect eggs by Pyenson & MacLeod (1936).

Summary.—Relation of mortality of bean weevil eggs to time of exposure and to temperature used can be expressed by two asymmetrical curves. The largest variation in percentage mortality of the eggs occurred in the middle portions of the curves and decreased toward each end of the curves. Due to the asymmetry of the two curves the smallest errors in terms of time or temperature of exposure, *i.e.*, dosage equivalents, was in the case of variable temperatures in the high mortality range and in the case of variable time of exposure in the low mortality region.

The resistance of eggs to high temperatures increased with the age of the eggs. Eggs surviving high temperature exposures were delayed in hatching and the amount of delay was directly proportional to the resultant mortality for any given treatment.—10-5-37.

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Homologs of Paris Green

IV. Insecticides Prepared from Animal and Vegetable Oils

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Considerable research work has been done on the preparation of insecticides, homologs of Paris green, from commercial oils of vegetable, animal and fish origin. Preparation of the individual copper-arsenite compounds of the saturated and unsaturated series of fatty acids has been described (Dearborn 1935, 1936, 1937). The object of this paper is to describe the preparation and to give some of the chemical and physical properties of the insecticides prepared from a few of the commercial oils.

As is well known, the oils of vegetable, animal and fish origin are made up of the glycerides of the fatty acids. Coconut oil, for example, contains a mixture of the glycerides of the following saturated acids:

caproic (2 per cent), caprylic (9 per cent), capric (10 per cent), lauric (45 per cent), myristic (20 per cent), palmitic (7 per cent), stearic (5 per cent), and oleic (2 per cent), the latter an unsaturated acid. On the other hand, there are oils that are composed mainly of the glycerides of the unsaturated fatty acids. Linseed oil, for example, contains approximately 90 per cent of glycerides of unsaturated acids. Most of the oils, however, are mixtures of glycerides of the saturated and unsaturated fatty acids. Hence, when an insecticide is prepared from an oil, copper arsenite compounds of all the fatty acids present are formed simultaneously and intimately mixed. An individual oil varies somewhat in its composition, depending upon its source and method of extraction, but it usually contains the same glycerides; therefore, an insecticide prepared from a given oil will generally contain the same homologous compounds. The comparative compositions of typical fats and oils experimented with in this paper have been published by Craig (1933). Castor oil (Ebner & Münzing 1925), however, differs from the other oils in that it is composed mainly of the glyceride of ricinoleic acid, which is a hydroxy acid.

Method of preparation.—The procedure used in preparing a copper arsenite insecticide from an oil differs slightly from that described in the writer's previous papers. The first step is to saponify the oil completely with an alkali. A solution of an alkali arsenite is then added in slight excess (about 10 per cent) of the theoretical amount required to produce compounds of the general formula 3 $CuAs_2O_4 \cdot Cu$ (acid anhydride) as calculated from the composition of the oil (Craig 1933, Ebner & Münzing 1925). The mixture is diluted to the proper degree and well agitated while being heated. The excess alkali is partially neutralized by the addition of a dilute mineral acid, and then the calculated amount of a copper salt dissolved in water is slowly added with vigorous agitation. When all the copper-salt solution has been added, the reaction mixture should be neutral or slightly alkaline in reaction, and if not it is adjusted. The mass is heated with vigorous agitation until the color changes from an olive green to a bluish green and coagulation takes place, when it is allowed to stand with occasional stirring until cold. When sufficiently cooled, the reaction mass is made acid to litmus paper by the addition of a dilute mineral acid and agitated for about one hour to dissolve any copper oxide or uncombined cupric arsenite that may be present, after which it is filtered and washed.

The product as precipitated is composed of aggregates too large for efficient insecticidal use and must be ground to the desired fineness. This is best accomplished by making a thin paste with water and grinding in a pigment or ball type of mill. The ground material is filtered, well washed and dried at a temperature preferably below 100° C. If the dried product contains lumps, they may be broken up in a pulverizing machine.

The insecticides as prepared above usually contain some uncombined copper salts of the fatty acids, the amount being dependent upon the care with which the various steps have been carried out. In drying the insecticides made from drying oils, such as tung, fish and linseed oil, care must be taken lest spontaneous combustion take place, especially when there is present considerable uncombined copper salts of the unsaturated fatty acids, as they have a great affinity for oxygen.

Physical and chemical properties.—All the copper arsenite compounds made from oils are greenish, and if properly prepared, ground, and dried, they will have a very fine, light and fluffy texture. They are not easily wet by water, and possess good adhesive qualities. To suspend them in water a wetting agent must be employed. The most practical method now known consists in wetting the dry compounds with alcohol. Denatured alcohol, even 50 per cent or less by volume, will cause the insecticides to be wet by water. Only just enough alcohol to form a thin paste is required. It has been found that the addition of a solution of

Table 1.—Chemical analysis of cupric arsenite compounds prepared from various oils.

Oil	Per Cent Total Arsenious Oxide		Per Cent Total Copper Oxide		Per Cent Water-soluble Arsenious Oxide	
	Found	Calculated	Found	Calculated	Without Glue	With 5 Per cent Glue
Castor	36.9	37.3	20.1	20.4	.3	.1
Coconut	41.4	45.6	23.2	24.4	.8	.3
Cottonseed	37.	41.	21.8	22.	.9	.9
Corn	37.9	38.3	20.6	20.5	.2	.2
Fish (menhaden)	38.6	40.7	23.2	22.8	1.9	1.9
Linseed	37.4	39.2	22.6	21.6	.6	.6
Palm	40.4	41.6	21.7	21.3	1.	.8
Peanut	37.8	40.3	21.2	21.6	.3	.1
Rapeseed	34.	39.2	19.	21.	1.1	.8
Sesame	35.5	39.7	20.1	21.3	1.	1.
Soybean	37.9	38.8	20.5	20.8	.6	.6
Tung	30.4	37.4	18.8	20.	.1	.1

bone glue or gelatin greatly improves the suspension in water, and also has a tendency to repress hydrolysis of the compounds. The amount of dry glue or gelatin to be used may be as little as 2 per cent of the dry weight of the insecticide used, but more may be used advantageously.

The analyses of typical insecticides prepared from oils are given in table 1. All the oils were refined oils, and the other ingredients were of technical grade. The analyses were carried out as described in previous papers (Dearborn 1935, 1936, 1937). Table 1 also gives the theoretical composition of the insecticides as calculated from the composition of the oils (Craig 1933, Ebner and Münzing 1925). The water-soluble arsenic was determined (1 gram per liter) after wetting with alcohol, with and without the addition of bone glue.

Samples of linseed-oil green and peanut-oil green were ground in a small Day pigment mill prior to determining their particle size distributions[1] by the method of Goodhue & Smith (1936). Fifty per cent alcohol was used as a suspending medium, and sodium citrate (.03 per cent) was used as a deflocculant. For comparison, the particle-size distribution of a sample of a commercial Paris green was determined by the same method. This brand was believed to consist of finer particles than any

[1] These distributions were determined by L. D. Goodhue, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.

other on the market in 1936. The observed particle size distributions of the three samples are given in table 2, together with their densities. The results show that the greens prepared from linseed oil and peanut oil can be ground to a finer and fluffier state of subdivision than that existing in the finest commercial Paris green obtainable. According to figures obtained by Goodhue, the two oil greens were approximately equivalent to the average commercial sample of calcium arsenate in proportion of particles below 10 microns in size.

Insecticidal effectiveness.—Few insecticidal tests have as yet been made with the greens prepared from oils or with any of the other homologs of Paris green. Fleming & Baker (1936) found lead arsenate more effective against the Japanese beetle than Paris green or its homologs. On the contrary, Fassig & Campbell (1937) found Paris green and its homologs more effective than lead arsenate against the confused flour beetle. In the latter tests the greens prepared from oils were more effective than the lower members of the acetic acid series, including Paris green.

Table 2.—Particle-size distribution of three arsenical-fatty acid insecticides.

Particle Size microns	Percentage by Weight between Indicated Diameters Linseed Oil Green	Peanut Oil Green	A Commercial Paris Green
Above 40	3	15	10
40–30	3	12	6
30–20	12	9	18
20–15	6	3	16
15–10	8	0	15
Below 10	68	61	35
Density, g./cc.	*1.80*	*1.82*	*3.3*

Summary.—Insecticides, homologs of Paris green, can be prepared from oils of vegetable or animal origin. The products are bluish green, insoluble in water, and after once dried are not easily wet by water without the use of a wetting agent, such as alcohol.

Addition of a solution of bone glue or gelatin to a water suspension of the insecticides improves the quality of the suspension and tends to reduce the amount of hydrolysis of the compounds.

These insecticides can be ground to a very fine state of subdivision, producing a light, fluffy product.—5-17-37.

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New Wetting and Spreading Agent for Spray Materials

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In experimental work with sprays to control the European corn borer the need arose for a safe wetting and spreading agent. At the request of the Connecticut Agricultural Experiment Station the Atlantic Refining Company prepared a series of samples of petroleum oil sulfonates in 1935. After laboratory and field tests one of the samples was selected as most suitable and has been manufactured commercially during 1937. The preliminary work in 1935 and 1936 showed that this material, among others, was effective as a wetting and spreading agent for spray materials (Batchelder 1937, Turner 1937). The material is manufactured and sold as *Ultrawet*. This report gives results of studies carried out by

Table 1.—Angle of contact measurements.

Concentration, Per Cent	Angle of Contact, Degrees			
	15 Sec.	45 Sec.	60 Sec.	120 Sec.
2.	74	73	72	70
1.	52	51	53	49
.5	72	65	63	55
.25	80	71	66	56
.1	109	100	98	96
.05	130	121	117	107

the Crop Protection Institute and the Connecticut Agricultural Experiment Station. Although much of this work is still in the experimental stage, sufficient evidence has been accumulated to show that *Ultrawet* possesses definite promise as a wetting and spreading agent, and that its use is of practical value.

Ultrawet is a sodium salt of water-soluble sulfonic acids made by acid treatment of petroleum. It is prepared in dry powdered form and is hygroscopic. It is approximately neutral, having a pH of $7 \pm .2$. It possesses desirable properties, such as compatibility with hard water, various contact and stomach poisons and fungicides and relatively low surface tension and angle of contact. Several laboratory samples made during a period of two years and two lots from commercial production have been uniform in properties.

[1] The experiments on European corn borer, onion thrips and apple scab were carried out jointly by the Crop Protection Institute and the Connecticut Agricultural Experiment Station. The detailed data will be published later by the station.

[2] Early publication of this paper has been secured by payment of the printing charge.

Wetting and spreading properties.—The surface tension of solutions of *Ultrawet* in distilled water in concentrations from .1 per cent to 1 per cent was from 34.7 to 36.2 dynes per centimeter. At a concentration of .05 per cent the surface tension was 37.7 dynes per centimeter. The angle of contact was determined by the method described by O'Kane (1931). The determinations using nasturtium leaves are given in table 1. The results showed that at lower concentrations the angle of contact decreased on standing.

Table 2.—Pea aphid control.

Material	Av. No. Aphids per Plant	Per Cent Control	Host Injury
Cubé, 3 lbs. per 100 gals.	2.1	93.5	none
Same, with *Ultrawet* ½ lb. per 100 gals.	.42	98.7	none
Same, with *Ultrawet* 1 lb. per 100 gals.	.38	98.8	none
Check	32.5		none

Further observations were made with leaves of plants using a visual method of evaluating wetting and spreading. The results showed that bean, potato and apple leaves were readily wetted with dilutions ranging from 1:1600 to 1:2400. Leaves with more waxy surfaces, such as peach, cabbage and nasturtium, required dilutions of 1:800.

All of these results indicated that *Ultrawet* had desirable wetting and spreading properties.

Effect of *Ultrawet* on plants.—*Ultrawet* has been tested on a wide variety of greenhouse, vegetable and orchard plants. At a dilution of 1:1600 *Ultrawet* caused no injury to tomato, potato, turnip, cabbage, onion, squash, bean, pea, corn, cantaloupe, tobacco, grape, apple, pear, peach, rose, coleus, snapdragon, begonia, ageratum and nasturtium. Injury appeared on corn, peach, grape and pear at a dilution of 1:800.

Table 3.—Potato flea beetle control.

Material	No. Feeding Marks on 100 Sq. Cm. Leaf Surface	Per Cent Reduction
Derris-clay, .75% rotenone	282	59.3
Same, with *Ultrawet* 1:1000	119	82.2
Check	693	
Cubé, 3 lbs. to 100 gals.	511	49.6
Same, with *Ultrawet* 1:1600	234	76.8
Check	1015	

Table 4.—Control of European corn borer in sweet corn.

Material	Per Cent Reduction of Borers	Per Cent Borer-free Ears
First Generation		
Cubé, 4 lbs. per 100 gals.	77.9	65.4
Same, with *Ultrawet* 1:1600	74.5	72.
No treatment		37.
Second Generation		
Cubé, 4 lbs. per 100 gals.	84.9	70.
Same, with *Ultrawet* 1:1600	89.9	70.
No treatment		20.

Compatibility with insecticides and fungicides.—*Ultrawet* is compatible with nicotine, pyrethrum, derris and cubé root, arsenate of lead, calcium arsenate, dry and liquid lime sulfur, and Bordeaux mixture. *Ultrawet* mixed with finely ground flowers of sulfur at 1:16 produced an excellent wettable sulfur. It is not an effective emulsifying agent for petroleum oils.

Experiments to control insects.—In most of the tests of *Ultrawet* in

combination with insecticides, the dilution has been 1:1600 by weight. This dilution gives satisfactory wetting and spreading on most plants and causes no injury to the plants. Preliminary laboratory tests indicated that *Ultrawet* added to suspensions of pure ground derris and cubé root increased the effectiveness of these materials. Moreover, *Ultrawet* did not cause any deterioration in toxicity of rotenone-bearing materials. Combinations of *Ultrawet* and rotenone-bearing materials were used in most of the field tests. In all cases in which derris or cubé were used in sprays, the materials were pure ground root containing 4 per cent rotenone and 14 per cent total extractives.

Table 5.—Control of European corn borer in potatoes.

Material	Per Cent Control
Cubé, 4 lbs. per 100 gals.	63.5
Same, with *Ultrawet* 1:1600	85.
Bordeaux mixture, 4:4:50	18.6
Same, with *Ultrawet* 1:1600	10.8
Bordeaux–calcium arsenate, 3 lbs. per 100 gals.	61.4
Same, with *Ultrawet* 1:1600	81.5
Bordeaux–cubé, 4 lbs. per 100 gals.	59.5
Same, with *Ultrawet* 1:1600	92.3
Bordeaux–Paris green, 1 lb. per 100 gals.	84.5
Same, with *Ultrawet* 1:1600	78.

Table 6.—Control of onion thrips.

Material	Av. No. Thrips per Plant	Per Cent Control
First Experiment		
Cubé, 4 lbs. per 100 gals.	63.4	61.8
Same, with *Ultrawet* ½ lb. per 100 gals.	34.7	79.1
Check, no treatment	169.5	
Second Experiment		
Cubé, 4 lbs. per 100 gals.	568.2	15.5
Same, with *Ultrawet* ½ lb. per 100 gals.	255.9	61.3
Cubé, 4 lbs. per 100 gals.; sulfur–*Ultrawet*,* 8 lbs. per 100 gals.	286.3	56.4
Sulfur–*Ultrawet*.* 8 lbs. per 100 gals.	450.6	31.4
Check, no treatment	656.7	
Third Experiment		
Cubé, 4 lbs. per 100 gals.; *Ultrawet*, ½ lb. per 100 gals.	23.8	86.3
Cubé, 4 lbs. per 100 gals.; sulfur–*Ultrawet*,* 8 lbs. per 100 gals.	65.4	62.4
Check, no treatment	174.2	

* 300-mesh dusting sulfur and *Ultrawet* mixed dry before diluting in the proportion of 16 parts of sulfur to 1 part of *Ultrawet*.

Pea Aphid, *Illinoia pisi* Kalt.—Early garden peas moderately infested with pea aphids were sprayed on June 9 and June 17. Five days after the second application the aphids on the plants were counted. The results are summarized in table 2.

The addition of *Ultrawet* increased the percentage of control, but *Ultrawet* at 1:800 was no more effective than 1:1600. No yield records were taken because ladybird beetles reduced the number of aphids soon after the counts were made.

Potato Flea Beetle, *Epitrix cucumeris* Harris.—Irish Cobbler potatoes heavily infested with potato flea beetles were treated on May 27 and June 3. The materials used were cubé in sprays and derris in dusts. *Ultrawet* was added to one dust at the rate of 1:1000, and to one spray at the rate of 1:1600. The effectiveness was determined by counting the feeding marks on 100 disks punched from the leaves, each disk being 1 square centimeter in area. The control is calculated by comparison with untreated checks. The results are given in table 3, and show that the dusts were more effective than the sprays. The addition of *Ultrawet* to either dusts or sprays increased the effectiveness considerably. It is believed that this has an application in control of flea beetles on tobacco.

EUROPEAN CORN BORER, *Pyrausta nubilalis* HÜBN.—Sprays were applied to both early and late sweet corn for control of the first and second generations of the corn borer. Applications were made according to the schedule suggested by Turner (1937). The results are summarized in table 4.

The addition of *Ultrawet* to cubé gave somewhat better results, especially in percentage of borer-free ears in the first-generation test.

Experimental sprays to control the European corn borer in potatoes were applied twice to Irish Cobbler potatoes. The plants were cut open and the number of borers counted. The results are summarized in table 5, in which the control has been calculated by comparison of treated and untreated plants.

In three tests *Ultrawet* added to the spray material substantially increased the percentage of control. In the case of Bordeaux mixture no insecticide was used. In the case of Paris green *Ultrawet* did not increase the degree of control.

ONION THRIPS, *Thrips tabaci* LIND.—Three field experiments were carried out on onion thrips, two with onions grown from sets and one with onions grown from seed.

In the first experiment, onions (sets) heavily infested with thrips were sprayed on June 16, June 25 and July 1. Thrips were counted at various intervals during this experiment, usually two days after spray applications. The final counts were made five days after the third spray. The thrips were counted on 25 plants in each plot and the effectiveness of treatments calculated by comparison with untreated checks. The materials used were cubé and cubé–*Ultrawet*. In a second experiment, onions (sets) severely infested with thrips were sprayed on July 8 and July 16. The materials used in this experiment were cubé, cubé–*Ultrawet*, cubé–sulfur–*Ultrawet*, and sulfur–*Ultrawet*. Counts and calculations were made as described for preceding experiment. A third experiment was carried out on onions (seed) lightly infested with thrips at the start. Sprays were applied July 16, 23, 30 and August 6. The materials used were cubé–*Ultrawet* and cubé–sulfur–*Ultrawet*. Results are given in table 6.

In all experiments the addition of *Ultrawet* at the rate of 1:1600 resulted in a marked increase in percentage of control. The results were particularly satisfactory in the third experiment because the first spray was applied before the plants were seriously damaged by thrips. In the second experiment the addition of sulfur to cubé increased the degree of control after the first application, which was made on a hot day. The second application was made in cooler weather and the sulfur was not effective. The same was true in the third experiment, in which all sprays were applied on days when the temperature did not reach 90° F.

No yield records were taken in the experiments on onions grown from sets, because the plants were killed prematurely by downy mildew, *Peronospora destructor* (Berk.) Caspary. The onions grown from seed were also killed prematurely by the same fungus, but in this case the sprays were applied early enough to prevent damage by thrips. The yield from the cube–*Ultrawet* block was 130 bushels per acre more than from the adjoining check block.

Tests with miscellaneous truck crop pests.—Cubé dusts (.75 per cent rotenone) and sprays (3 pounds per 100 gallons) were used to control the Mexican bean beetle, *Epilachna varivestris* Muls., the striped cucumber beetle, *Diabrotica vittata* Fab., the imported cabbage worm, *Pieris rapae* L., and the cabbage looper, *Autographa brassicae* Riley, both with and without *Ultrawet*. In most cases the addition of *Ultrawet* did not result in increased protection of the plants from these pests. The sprays and dusts without *Ultrawet* usually provided adequate control.

Apple Scab, *Venturia inaequalis* (Cooke) Winter.—Laboratory tests showed that *Ultrawet* exhibited fungicidal action on certain fungus spores. Following this discovery, field experiments were carried out to control apple scab. In one plot *Ultrawet* was used with lead arsenate and dry lime sulfur (one-half the recommended strength). This treatment was compared with lead arsenate–dry lime sulfur (full strength) in an adjoining plot. Applications were made May 24, June 4, 14, and July 9. Results are given in table 7.

Table 7.—Summary of apple scab control.

Treatment	Variety	Per Cent Control	Foliage Injury
Dry lime sulfur 6 lbs., lead arsenate 3 lbs. per 100 gals.	McIntosh	85.4	considerable
	Rome Beauty	95.7	slight
Dry lime sulfur 3 lbs., lead arsenate 3 lbs., *Ultrawet* ½ lb. per 100 gals.	McIntosh	84.4	very slight
	Rome Beauty	91.2	none
Check	McIntosh	7.6	none

The full strength lead arsenate–dry lime sulfur treatment was slightly superior in respect to scab control, but the difference was not significant. The foliage in the plot treated with lead arsenate–dry lime sulfur–*Ultrawet* showed considerably less spray injury, especially on the McIntosh variety.

Fruit analysis made at harvest showed that both sprays were retained in sufficient amounts to control scab and insects; in fact, both were above the tolerance for lead on the McIntosh.

These results indicate that the amount of fungicide may be reduced with the addition of *Ultrawet* to the spray.

Summary and conclusions.—A sodium salt of water-soluble petroleum oil sulfonates designated as *Ultrawet* possesses desirable qualities as a wetting and spreading agent for spray materials. *Ultrawet* at 1:1600 in water did not damage the foliage of many economic plants. *Ultrawet* is compatible with the insectides and fungicides in common use.

The addition of *Ultrawet* to cubé dust resulted in increased control of the potato flea beetle. The addition of *Ultrawet* to cubé root in sprays gave promising results in controlling onion thrips. The use of *Ultrawet* with cubé root in sprays to control the European corn borer gave slightly increased protection.

Ultrawet combined with half the ordinary strength of dry lime sulfur controlled apple scab nearly as well as full strength dry lime sulfur and

reduced injury to foliage caused by the lime sulfur–arsenate of lead combination.

Ultrawet added to sprays and dusts to control the Mexican bean beetle, striped cucumber beetle, imported cabbage worm and cabbage looper did not provide increased protection.

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Scientific Notes

Termites Infesting Turnips.—On May 14, 1937, in Orlando, Fla., the writer's attention was brought to a colony of termites, *Reticulitermes flavipes* Kol.,[1] which was attacking turnips (the edible roots) growing in the field. Upon further investigation it was found that about a dozen turnips in a small garden planting of two rows, each 20 feet long, were infested. Practically all of the infested turnips were found in one row planted within 3 or 4 feet of a garage with wooden sidings which made contact with the soil, and it is believed the wood in the garage was the source of infestation.

Several turnips were carefully examined, and it was found that the older and more "woody" roots were most heavily infested. The interiors of some of the older roots were completely tunneled, the work being similar to that in wood attacked by these insects. From one root, which measured 3 inches in diameter, 155 live worker and soldier termites were taken.

Max R. Osburn, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—8-9-37.

[1] Determined by T. Snyder, E.

Notes on the Grape Leaf Folder and its Parasites in the San Joaquin Valley.—In a brief account of a localized outbreak of the grape leaf folder, *Desmia funeralis* Hbn., in California in 1932, Donohoe & Barnes (1934) noted heavy larval parasitization by *Microbracon cushmani* Mues. Severe infestations of the insect in the fall of 1936 resulted in extensive damage, particularly to the late-maturing Emperor variety of grapes in Fresno and Tulare counties. In many cases, following complete destruction of the foliage, the larvae fed on the grapes. The latter attack, severe in itself, was followed by decay, and in some instances entire crops were rendered unmerchantable as fresh fruit.

The writers made a series of observations on parasites after the start of pupation of the overwintering brood. Parasitization of full-grown larvae by *Microbracon cushmani* was abundant in each of three widely separated infestations and approached 100 per cent by October 15. The average number of immature parasites per host larva was 8.3 on the basis of 44 records. Evidence was obtained that parasitization by *Microbracon* was reduced and grape leaf folder damage accentuated in vineyards dusted with calcium cyanide late in August and early in September for control of the grape leafhopper, *Erythroneura comes* (Say). Severe damage to grape bunches was noted only in cyanide-dusted vineyards.

Five species of parasites were reared from pupae collected during the fall and winter of 1936–37. These have been identified by the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, as follows: Hymenoptera, *Brachymeria ovata* (Say), *Ephialtes sanguineipes* (Cress.); Diptera, *Anachaetopsis tortricis* Coq., *Zenillia ceratomyiae* Coq., *Nemorilla maculosa* Meig.

Parasitization of the last fall brood of pupae by these five species varied with the location and date of collection. The maximum parasitization obtained was 50.7 per cent at

Parlier, Fresno county, October 4, 1936. There is evidence that each species parasitizes the larva, persists during transformation of the host, and emerges from the pupa. Oviposition in pupae has not been observed. *Ephialtes sanguineipes* and *Nemorilla maculosa* overwinter within the host pupae. No information on the method of overwintering has been obtained for the other three species.

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HEBER C. DONOHOE, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine*, and GEORGE H. KALOOSTIAN, *Fresno, Calif.*—9-7-37.

Sodium Lauryl Sulfate as a Contact Spray.—During May 1937 a very heavy infestation of *Illinoia solanifolii* and *Myzus persicae* on sweet potato plants in a greenhouse at Opelousas, La., was completely cleaned up by a single application of a sulfated fatty alcohol (*Orvus W A Paste*) used at the rate of 2 liquid ounces per gallon of water. A remarkable kill was also obtained against the common greenhouse red spider on foliage of the sweet potato and dahlia, and of the red spider on citrus, at the same dilution. This material sprayed direct into open flower blooms killed the flower thrips at once with no burning or staining. Greenhouse ants were killed immediately when wet with the spray as were also millions of adult mosquitoes. A single application against the scale *Eriococcus azaleae* on azalea bushes in commercial nursery and against the citrus whitefly, *Dialeurodes citri*, gave evidence of a good kill with no apparent injury. These results indicate that this material, in addition to its use as a wetting-out, penetrating and spreading agent with certain sprays, shows an extremely effective killing power against many soft-bodied insects when used alone at strong dilutions. It seems to have little effect on sow bugs and several kinds of beetles.

HERBERT L. DOZIER, *Louisiana Department of Agriculture and Immigration, Opelousas.*—8-19-37.

Sweet Potato Root Weevil Overwinters as Adult in Louisiana.—On Nov. 25, 1936, two 3×6 foot screened ground cages were sunk in typical headland and ditch bank at Sunset, La., and 500 active adult *Cylas formicarius* placed in each. A cold spell on December 8 made the majority disappear but as soon as it warmed up the next morning a good percentage reappeared and were observed actively feeding on a few sweet potatoes retained in each cage. On December 24 these badly punctured potatoes were replaced by a few new ones and were placed in small cages indoors where large numbers of weevils developed in them, demonstrating that egg-laying had taken place freely during the month exposed.

All potatoes were removed from both cages on January 10, 1937; leaving only the natural vegetation, such as bull grass, Bermuda grass, goldenrod and ragweed, available as possible food. Adults were observed in these cages on April 8 but in greatly diminished numbers and none appeared to feed on a few fresh potatoes placed in cage on April 20. This shows, however, that *Cylas formicarius* can winter over in enormous numbers in the heart of the sweet potato belt in Louisiana, during a mild winter at least, and live without sweet potatoes as food for at least three months. This evidence shows that the recommendation to plow headlands and burn ditch banks to reduce the weevil winter carryover is based on actual facts.

HERBERT L. DOZIER, *Louisiana Department of Agriculture and Immigration, Opelousas.*—9-15-37.

***Tyroglyphus longior* Gerv. on Cultivated Mushrooms.**—A species of mite which appears to be specifically identical with *Tyroglyphus longior* Gerv., as described by A. D. Michael (1903) and Nathan Banks (1906), has been found commonly attacking cultivated mushrooms. All specimens of *Tyroglyphus* collected from cultivated mushrooms by the writer to date, including series from mushroom houses near Seattle, Wash., Chicago, Ill., and Kennett Square, Pa., prove to be the same species.

All mites of the genus *Tyroglyphus* found attacking cultivated mushrooms in this coun-

try have heretofore been referred to *Tyroglyphus lintneri* Osb., a species which was described from specimens taken in a mushroom planting in New York. No specimens which could be referred to this species with any certainty have been seen by the writer.

According to studies made by Michael and Banks, *T. longior* may be distinguished from *T. lintneri*, as described, by the pectinate body bristles. Although the pectinations of these bristles are minute, they may be observed readily, with the aid of the low-power binocular, in living specimens or dry mounts. They are difficult to detect, however, in the instance of specimens mounted in balsam or other media.

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A. C. DAVIS, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.* —8-19-37.

Rose Leaf Beetle in Pennsylvania.[1]—*Nodonota puncticollis* Say was recorded from Pennsylvania by Horn (1892). Stear (1920) first noted its injury to apple fruits. Manuscript notes of S. W. Frost reveal its increasing importance as an apple pest in south-central Pennsylvania from 1919 to 1935. Worthley (1937) reported the results of a survey of Adams county orchards by Merrill Wood in 1936.

Table 1.—Tests of lead arsenate against rose leaf beetle on apple. Tyson orchard, Idaville, Pa., 1937.

TREATMENT NO.	MATERIALS	AMOUNTS PER 100 GALS.				
		Petal-fall May 21	Seven day May 28	First cover June 7	Second cover June 17	Per cent injured fruit June 21–24
1	Lead arsenate,* lbs.	3		3	3	1.
2	Lead arsenate,* lbs.	3	3	3	3	.4
3	Lead arsenate,* lbs.	6	6	3	3	.3
4	Lead arsenate,* lbs.	6	6	3	3	
	Soybean flour, lbs.	1	1	1	1	.5
5	Sprayed without supervision, 5–6 gals. per tree, lead arsenate,* lbs.	2.5	2.5	2.5	2.5	2.2

* A brand containing casein, to which hydrated lime was added except in treatment 4. All treatments received liquid lime sulfur at 2.5 gallons per 100 in the petal-fall, 2 gallons per 100 in the first cover, and 1.5 gallons per 100 in the second cover.

Suspected larvae were found upon the roots of sweet clover in the summer of 1936. Two beetles were recovered from cages placed over these plants in the spring of 1937. Extensive digging in late May 1937 revealed pupae of this species in bare, oval earthen cells measuring 6 by 4 mm., and located one-quarter to 1 inch below the ground surface among the roots of red clover, sweet clover and pasture thistle in apple orchards. They were not found under dock, wild onion, wild strawberry, shepherd's purse, goldenrod, rattlesnake weed, broad-leaved plantain or English plantain, plants that were also present in the ground cover. Newly formed adults found in pupal cells were of a raw sienna brown color. The normal iridescent greenish or cuprous color was assumed before leaving the ground, and in one individual observed took 10 hours to develop, appearing first in the eyes, mandibles and pronotum.

In 1937 beetles emerged from the ground over an 11-day period beginning May 28. They were seen mating from June 5 to July 16, and by July 20 were difficult to find. Con-

[1] Authorized for publication on August 31, 1937, as paper 784 in the journal series of the Pennsylvania Agricultural Experiment Station.

tinued observation during this time failed to reveal their oviposition habits, either in the field or in cages with suspected host plants.

The beetles first fed upon the corollas of red clover, alsike clover and wild rose, and the leaves of pasture thistle. On June 6, when red clover was in full bloom, the beetles first attacked the fruits of apple, and the attack continued until June 22. Early varieties, and clusters of apples on the outer branches, appeared to be preferred. As the beetles left apple they attacked the green seed pods of dock. Feeding was also observed on the flowers of red osier dogwood and white clover, and on the leaves of white avens, peach and plum.

In one Adams county orchard a block of mature York Imperial trees that was sprayed twice during the period of beetle attack in 1936 with lead arsenate, 2 pounds per 100 gallons, at the rate of about 4 gallons per tree, showed 23 per cent injured fruit. In 1937 various treatments were applied to single rows in this block, and replicated four times. Sprays were applied by the grower under supervision, and averaged 8.5 gallons per tree per application. All the fruit (a light crop) on 160 trees was scored for beetle injury before the "June drop." Although red clover beneath the trees was well populated by the beetles, all treatments kept beetle injury at a low point, as shown by the figures in table 1. Even the general spraying of the orchard, as represented by treatment 5, gave far better protection than the less adequate schedule of 1936. Good coverage with lead arsenate, 3 pounds per 100 gallons, appeared to be sufficient, for increased dosage and the addition of soybean flour as a sticker showed no benefit. Starting to build the spray coverage before beetle attack helped to protect the apples (compare treatments 1 and 2). The sprays seemed to be of value chiefly as repellents, and no dead beetles were caught on sheets spread beneath the trees. Beetles were killed in numbers, however, when they continued to feed upon the leaves of young plum trees sprayed with lead arsenate.

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Merrill Wood and H. N. Worthley, *Pennsylvania State College, State College.*—9-9-37.

Starvation of Developing Parasites as an Explanation of Immunity.—In undertaking an investigation of the causes of immunity, it is not, at first, necessary to postulate a defensive reaction on the part of the host or the lack of counteraction on the part of the parasite. There is some evidence that immunity may be due to inanition or starvation of the parasite.

Muesebeck & Parker (1933) in their study of *Hypersoter disparis* as a parasite of the gypsy moth found that many of the eggs and larvae of the ichneumonid failed to develop. This fact suggested that the adaptation of this parasite to the body content of the gypsy moth caterpillar was not complete. They state that, "Apparently the egg or larva of the parasite dies before encystment occurs, perhaps because the medium in which the parasite finds itself is not altogether suitable for its development."

A similar situation occurs in various species of coccids, *i.e., Pseudococcus gahani, P. citri, Coccus hesperidum,* etc., when attacked by certain chalcidoids.

A simple explanation to account for the unsuitability (immunity) of a host for the complete development of a parasite is that, as food, it is inadequate. In an unsuitable host the parasite succumbs while it is in a stage of rapid growth either as an embryo or larva. Larvae that are not developing or growing are known to live for long periods in hosts unsuitable as food. For example, the planidium of *Perilampus hyalinus,* a parasite of *Limnerium validum,* is able to live for a considerable period within the body cavity of the fall webworm, *Hyphantria cunea.*

Since the food requirements of parasitic insects differ, it is reasonable to assume that such requirements determine the suitability of a host for a parasite in much the same way that the food requirements of the Mediterranean fruit fly determine the kinds of fruit in which it can develop.

The writer (Flanders 1937) recently found that the sexes of certain chalcidoids require different hosts. The female larvae of *Coccophagus scutellaris,* for instance, live in the body

fluids of lecanine scale insects; the males in the body fluids of hymenopterous parasites. The body fluids of the scale insects are unsuitable for the development of the male, evidently being inadequate as food.

When unfertilized, as well as fertilized, eggs of *Coccophagus gurneyi* are deposited in a single individual of an immune host such as the mealybug *Pseudococcus citri*, embryonic development is completed in about three days. The fertilized (female) eggs hatch but the larvae soon die and are encysted. The unfertilized (male) eggs do not hatch as long as they are surrounded by the body fluids of the mealybug. The unhatched larvae, however, remain alive for long periods with no evidence of the slightest immune reaction on the part of the host. Cendaña (1937) noted that such a larva that had lived for 80 days within a mealybug had molted once although no growth had occurred. It is not likely that a defensive reaction on the part of the mealybug would affect only the fertilized eggs and the larvae therefrom. The mealybug is unsuitable for the development of both the male and the female. The female dies, probably from starvation; the male lives since it is adapted to exist for long periods with little, if any, food.

The degree of immunity of various hosts to the progeny of a parasite does not appear to be correlated with their phylogenetic relationship but only with their physiological makeup.

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S. E. FLANDERS, *University of California Citrus Experiment Station, Riverside.*—9-7-37.

Food Plants of *Nodonota puncticollis* Say.—Within recent years, various plants in the Hudson river valley have suffered rather heavy attacks from adults of the so-called rose leaf beetle, *Nodonota puncticollis* Say. An effort has been made to determine the food plants of the adult and larva.

Larvae and pupae were found during the spring of 1937 among the roots of the following plants growing in relatively dry soil: *Trifolium agrarium* L., hop clover or yellow clover; *Potentilla canadensis* L., cinquefoil or five-finger; *Hieracium pratense* Tausch., king devil; and *Hieracium aurantiacum* L., devil's paintbrush or Grim the Collier. This is probably an incomplete list of larval food plants.

Table 1.—Plants on which adult rose leaf beetle feeds in Hudson river valley.

HOST	AMOUNT OF INJURY NOTED ON VARIOUS PLANT PARTS		
	Flowering Parts	Fruits	Foliage
Apple		severe	slight
Peach		severe	slight
Pear		severe	slight
Blackberry			severe
Raspberry			severe
Strawberry			severe
American elm			moderate
Basswood			moderate
Hackberry		slight	slight
Chokecherry		slight	slight
Cinquefoil			severe
Virginia creeper		slight	slight
Peony	slight		
Rose	slight		
Dogwood shrubs			
Cornus stolonifera Michx.	severe	severe	severe
Cornus paniculata L'Her	severe	severe	moderate
Cornus alternifolia L.		severe	moderate

Emergence records of the adults were taken from cages placed over hop clover, cinquefoil and king devil weed. A maximum of 30, minimum of .5, and average of 5.3 beetles per square foot was recorded from 76 square feet of soil caged during 1937. Unpigmented adults, pupae and full-grown larvae were found in the soil on May 27 and the last larvae on June 19.

The earliest record of beetles appearing on plants was May 25 in 1936. During 1937 the first adults emerged in cages June 1, with the greatest emergence occurring between June 5 and 10. The last adults emerged in cages June 25. Adults were observed to feed first on dogwood shrubs growing near the reported food plants of the larvae and were later noted on a variety of plants. Beetles were feeding in greatest numbers during the second and third weeks of June in orchards containing or adjoining extensive growths of the larval food plants. No feeding was observed in orchards after July 4, 1937. The last adults were seen resting on dogwood shrubs July 20, 1937.

Adults feed either singly or in groups. As many as a dozen beetles may be found feeding on a single fruit of apple, pear or peach. They leave shallow, finely chiseled scars on pear and apple fruits, but deep wounds are also produced on the latter. As a rule the feeding injuries on peach fruits are rather deep. The plants on which adults may feed in this area are given in table 1. Adults were also found resting upon a number of plants other than those listed and may occasionally feed on them.

The plants injured by the adults almost invariably were located in close proximity to the plants listed as harboring the larvae. Thus examinations of *C. stolonifera* shrubs, a favorite adult host, growing approximately one-fourth mile from extensive growths of the larval hosts were found practically free of feeding. This may indicate that beetles travel only short distances in search of food.

ACKNOWLEDGMENT.—Many of the plants mentioned in this note were kindly identified by Dr. Edith Roberts, Chairman, Department of Botany, Vassar College.

HAROLD M. STEINER and P. J. CHAPMAN, *New York State Agricultural Experiment Station Geneva.*—8-23-37.

Leafhoppers and Homoptera of Related Families Collected in and Adjacent to Narcissus Plantings.—For the past three years the writer has studied the insect fauna of narcissus plantings in connection with an investigation of the possible insect vectors of the disease known as narcissus mosaic. This note deals with the families Cercopidae, Membracidae, Cicadellidae, Fulgoridae and Psyllidae. Twenty species representing these families have been observed feeding on narcissus while others have been taken in narcissus fields with an insect net. On a few occasions nymphs have been seen on narcissus, especially where fields had not been cleanly cultivated. From observations made thus far, not a single species prefers narcissus to the native host, but uses it as an incidental or transitory host. Some of the species found to feed on narcissus are commonly taken in narcissus plantings, but more commonly in fields of weeds or in adjacent woods.

The species found to feed on narcissus are as follows: *Aceratagillia sanguinolenta* (Prov.), *Agallia constricta* Van D., *Aphalara calthae* (L.), *Aphrophora quadrinotata* Say, *Chlorotettix unicolor* (Fitch), *Chlorotettix viridius* Van D., *Cicadula divisa* (Uhl.), *Draeculacephala mollipes* (Say), *Empoasca erigeron* DeLong, *Empoasca fabae* (Harr.), *Graphocephala coccinea* (Forst.), *Philaenus leucophthalmus* (L.), *Philaenus lineatus* (L.), *Phlepsius irroratus* (Say), *Platymetopius acutus* (Say), *Platymetopius frontalis* Van D., *Polyamia inimica* (Say), *Stictocephala festina* (Say), *Stobaera tricarinata* (Say) and *Thamnotettix nigrifrons*, (Forbes).

In addition to these, many species of this group have been collected in woods and fields adjacent to narcissus plantings. A total of 157 species was collected in this work but will not be listed here.

In cage tests some species have been found to live on narcissus 10 to 15 days. These are *Aceratagallia sanguinolenta, Agallia constricta, Cicadula divisa, Draeculacephala mollipes* and *Empoasca erigeron. Graphocephala coccinea*, on the other hand, was found to live only a short time when restricted to a narcissus diet.

None of the species tried have shown any positive evidence that they were vectors of the virus causing narcissus mosaic.

F. S. BLANTON, *U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine.*—8-30-37.

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THE PROPOSED NEW CONSTITUTION AND BY-LAWS

PREVIOUS to the last annual meeting of the American Association of Economic Entomologists, a special committee submitted to the membership a proposed new Constitution and By-Laws. Few members, if any, were opposed to most of the provisions of this new Magna Charta for the guidance of our organization. Certain changes, however, proved to be exceedingly controversial in character and as a result no vote of the membership on its adoption was taken.

Because of a real need for certain changes in the present Constitution and By-Laws, the subject was left open for further consideration and later action by the simple expedient of adopting a series of recommendations. In substance these recommendations recognized the need for a restudy of the document, requested the appointment of another committee to prepare a revised draft and ordered the distribution of this redraft to the active membership in ample time for a careful study of it before the next annual meeting.

The next meeting of the Association is but a few days distant. The special committee has again expended much time and effort in producing a revised edition of this proposed new Constitution and By-Laws. This was submitted to the active membership during the summer and constructive suggestions were invited. In this issue of the JOURNAL there is published the most recent report of the special committee which pertains to final changes recommended to meet some of the criticisms advanced by the membership.

It is enlightening to note in reading this final report of the special committee that only 34 of 1143 members responded to the request for comments or constructive criticisms. Either the membership as a whole is so well satisfied with the new redraft as to make comment superfluous or it is willing to let "George" make the suggestions now and then protest later if the changes are not all that are to be desired.

Those members of the Association who have not already seriously studied the provisions of the proposed new Constitution and By-Laws should do so at once. All members should read the special committee report in this issue of the JOURNAL. Only by such effort can the members attending the next meeting of the Association at Indianapolis be prepared to vote intelligently upon a matter of so vital importance to the Association and the best future interests of economic entomology.

It would be most unusual if all of us could agree on the wording and content of each article and section of the proposed revision. Enough thought and effort has gone into a consideration of the proposed major changes to eliminate the danger of omissions and errors of catastrophic proportions. Adoption of this proposed new Constitution and By-Laws,

perhaps with some additional changes here and there as may be advanced at the meeting, should be a boon to the further growth and development of the Association.

Report of the Special Committee on Constitution and By-Laws

MAJORITY REPORT

At the last annual meeting of the Association it was voted that the President appoint a Special Committee to consider the final re-draft of the Constitution and By-Laws of the Association to be made by the Executive Committee, and make recommendations to be submitted to the Association at the next annual meeting.

This re-draft was made and sent by the Secretary of the Association in midsummer to all members with the request that comments be in the hands of the Chairman of the Special Committee by September 10.

The following Special Committee was appointed by the President: A. F. Burgess, *Chairman;* W. E. Britton, Arthur Gibson, C. L. Metcalf and E. F. Phillips.

As a result of sending these notices to 1143 members, 34 replies were received. Eight of these accepted the draft as written and 26 made numerous suggestions concerning proposed changes. A meeting of the Special Committee was held October 20 at New Haven, Conn., all members being present with the exception of Professor Metcalf. The President and the Secretary of the Association were invited to attend this meeting. President Bishopp was unable to do so, but Professor Cory was present.

A full day was spent in discussing the re-draft and the suggestions for changes submitted by the members, and at the completion of the meeting those present unanimously approved the draft of the constitution revised by the Executive Committee with the following modifications:

Article II, Section 2.—In the last sentence delete the word "business" and substitute the words "official action." After the word "except" add the word "on." Delete the word "considered" and substitute the words "made public," so that this sentence will read "No official action except on routine matters shall be made public without approval of the Association."

Article II, Section 4.—In the first sentence delete the words "existing entomological society or" and the words "or any that may be formed hereafter" so that the sentence shall read "Any organization having aims and purposes in accord with those of the American Association of Economic Entomologists may petition this Association for affiliation by making formal application in writing." In the eighth sentence following the words "Executive Committee" delete the word "the" and substitute the word "such" so that the sentence shall read "After consideration and approval of the application by the Executive Committee such organization will be enrolled as an affiliated society after approval by the Association." Delete the last sentence in Section 4.

Article III, Section 3.—In the first sentence, second line, delete the words "Associate member" and substitute therefor the word "person" so that the sentence shall read "Active membership may be conferred at any annual meeting on any person who has made or is making substantial contributions to the progress of entomology, after nomination by the Membership Committee and approval by two-thirds of the Active members present."

Article III, Section 4.—Delete the last sentence.

Article III, Section 5.—After the words "member for life" insert the following "and members who have retained continuous membership for twenty-five years or more may also become members for life upon payment of $50.00. Such members," so that the section shall read "Any member who shall pay to the Association the sum of $100 shall become a member for life, and members who have retained continuous membership for twenty-five years or more may also become members for life upon payment of $50. Such members shall thereafter be exempted from dues and shall be furnished with the JOURNAL OF ECONOMIC ENTOMOLOGY without further charge."

Article III, Section 6.—This section has been revised to read as follows: "Section 6. Members in good financial standing have the right to resign. The right to terminate the membership of any member for due cause is reserved by the Association, but shall not be done, except for nonpayment of dues, until opportunity is given such member for defense before the Executive Committee."

Most of these changes have been made as a result of suggestions sent in from the members. The change in Article II, Section 2, removes the limitation concerning transaction of business but requires the approval of the Association before official action is made public. In Section 4 the changes in the first sentence simply eliminates words which seemed to be unnecessary and the change in wording in the eighth sentence makes the statement more specific. The last sentence in Section 4 seems unnecessary as the thought is already covered in the first sentence of this section.

Article III, Section 3 provides that any person may be made an Active member whose work and accomplishments warrant such action. This section lays down a general rule and will make it necessary for the Association to establish definite standards which can be modified by action of the Association when necessary without involving an amendment to the Constitution.

The last line in Section 4 eliminates the provision that all Foreign members shall be enrolled as Honorary members. Under the present Constitution all Foreign members are Honorary members and the Committee did not think it necessary specifically to provide in the Constitution for a transfer to Honorary membership.

The Committee felt that definite agreements or commitments that had been made by the Association should not be revoked except by mutual consent and on this principle it was decided that Branches and Sections which had been admitted to this Association under definite agreement that their executive officer would become a Vice President of the Association, should not be changed without mutual agreement; that the Associate members who automatically became Active members when the Constitution was revised so as to eliminate Associate membership, should continue as Active members and that Foreign members who had been admitted as Honorary members under the present Constitution should be transferred by vote of the Association to the Honorary list.

The change in Section 5, making it possible for those who had been members continuously for twenty-five years to become members for life by a payment of $50, seemed desirable not only for the membership, but for the best interests of the Association.

The Committee felt that Section 6 was not worded in such a way as to be clear, and that considerable confusion in its interpretation might result. It also felt that the Association had the right to terminate membership of any member who might carry on practices which were detrimental to the best interests of the Association, but that an opportunity

should be given for the member to present his case to the Executive Committee before action is taken.

The Committee recommends that the re-draft of the Constitution made by the Executive Committee with the exceptions above noted be approved by the Association.

A. F. BURGESS *Chairman*
W. E. BRITTON
ARTHUR GIBSON
E. F. PHILLIPS

MINORITY REPORT

I regret that I find myself unable to agree with my honored colleagues on this committee in two very important respects. Knowing that a considerable number of other members feel as I do about these matters, I present this minority recommendation in order that the members of the Association may have the alternate ideas brought to their attention at least for a full and fair consideration and possibly for adoption if the majority of the members agree that these ideas are better for the welfare of the Association than those presented in the majority report.

At the forty-eighth meeting of the Association in St. Louis, the Association abandoned the distinction between Active and Associate membership, because it was felt that the difficulty of distinguishing between the two groups was too great, that many injustices were done, and that there were so many "forgotten men" who were never advanced to Active membership because their merits were not appreciated or considered. According to the report of the Special Committee at the forty-eighth meeting, the letter vote was 50 to 1 to abolish the distinction between Active and Associate membership.

Now it is proposed to return to the previous practice and I do not find that the Special Committee has advanced any evidence to show that the judgment of the Association two years ago was faulty. I believe that all of the difficulties expressed by the Special Committee in paragraph 3 on page 245 of the JOURNAL for February 1936 still remain. As a matter of fact, the situation would be even a little worse now than formerly because we would advance with the additional possible injustice that, in the meantime, all who were Associate members at the time of the St. Louis meetings have become Active members, without ever having been subjected even to the indefinite and poorly defined tests formerly applied.

It seems to me probable that the decisive vote of the Association at the St. Louis meeting against Active and Associate memberships was not so much an objection to two classes of membership, *per se*, as to the method of selecting members for the higher classification. I do believe that there should be a distinction between Active and Associate membership in the Association. I believe that the right to vote and determine the policy of the Association should not be extended to all whom we might welcome to affiliate membership. I therefore propose as a substitute for Article III, Sections 2 and 3, the following ideas.

Article III, Section 2.—Anyone interested in the study or practice of entomology may become an Associate member upon recommendation of the Committee on Membership, after a regularly executed application, accompanied by the required fee and endorsed by

two Active members, has been filed with the Secretary-Treasurer, by a two-thirds vote of the Active members voting at any regular meeting.

Section 3.—Active membership may be conferred at any regular annual meeting upon any person interested in the study or practice of entomology, who is a graduate of a recognized or accredited college or university, and who has had three years of professional experience in entomology (such as employment in a federal, state or provincial department of entomology, experiment station or educational institution, or who has engaged in a professional, administrative or commercial work in entomology and closely related fields), subsequent to such graduation. Graduate study in entomology at a recognized or accredited institution may be substituted year for year for the required experience. All educational requirements may be waived for those who have had at least ten years' experience in professional, administrative or commercial entomological work. Qualified persons may be elected to Active membership at any annual meeting, upon recommendation of the Committee on Membership after a regularly executed application, accompanied by required fees and endorsed by two Active members, has been filed with the Secretary-Treasurer, by a two-thirds vote of the Active members voting at such regular meetings.

This is a definite, tangible yardstick by which the qualifications of a member for Active membership can be measured, and surely all who can qualify for Active membership as defined above are sufficiently acquainted with the aims and interests of the American Association of Economic Entomologists to be safely entitled to a vote in its affairs.

There are probably persons who desire affiliation with this Association whose chief or only claim to being called entomologists is *that desire*. I think we should welcome their affiliation as Associate members, but I do not think we should give opportunity to persons not qualified by training, or experience, as entomologists, to have a voice in the determination of Association policies, for it is conceivable that their numbers might become sufficient to outweigh the vote of those whose training and experience better qualify them to guide the Association wisely.

If the Association still wishes to make a distinction between those who have made "substantial contributions to the progress of entomology" the opportunity to do so is already available under the provision of Article III, Section 4, for Honorary membership. Let us use the rank of Honorary membership more freely than it has been in the past. It is, perhaps, fine for a few of our most revered entomologists to be designated Honorary members, but I believe much more good would accrue to the Association if a hundred or so of those whose names will occur to almost everyone as representing the "Royal Guard" of the Association, were to be designated Honorary members, without waiting until they are tottering into their graves. The wider employment of the Honorary membership is, however, not essential to the distinction between Active and Associate membership advocated above.

The second point in which I find myself unable to agree with the majority report is with reference to the Publication Committee. I believe it would be better for the Editor and Associate Editor to be nominated by the Executive Committee of the Association and elected by ballot of the Active members. The Executive Committee is made up of those persons presumably best informed and most interested in the needs and affairs of the Association. The members of the Publication Committee should be selected for their editorial ability in certain, special, restricted fields of entomology and might conceivably be very poorly informed and very little interested in the general policies of the Association. I believe,

also that the number of persons on the Publication Committee should be left flexible, so that, as new fields or special phases of entomology develop, it shall be possible to elect someone to represent these special phases on the Publication Committee. I believe, also, that it would be desirable to have a shorter term than five years for members of the Publication Committee. In case any member does not serve to the satisfaction of the Editor his place could more promptly be filled by someone who *would* function. If provision is made for the reelection of members of the Publication Committee, the desired continuity of service for capable and willing committeemen would be adequately provided for.

I would therefore suggest the following as a substitute for Article III, of the By-laws, Section 2:

Article III, Section 2.—The Editor, Associate Editor and Publication Committee shall be elected by the Association upon nomination by the Executive Committee, with the advice of the Editorial Board. The Publication Committee shall consist of ten or more members who shall be elected for terms of two years each, so arranged that half of the members are elected annually. There shall be no prejudice against reelection of members of the Publication Committee. The members of this Committee shall have an advisory relation to the above constituted Editorial Board.

This would make the Publication Committee a servant of the Editorial Board rather than make the all-important posts of Editor and Associate Editor the toys of the Publication Committee.

C. L. METCALF

Review

Statistical Methods, by George W. Snedecor. 341 pp., 1937. Collegiate Press, Inc., Ames, Iowa. $3.75.

How shall statistical methods be geared to the efficient utilization of data so that the novice will be able to manipulate the gears not only more intelligently but more easily than has been possible up to the present time? Statistics, data, novice—these are the factors that have motivated Professor Snedecor in the writing of this text.

The book as a whole is comprehensive and profusely illustrated with practical research problems. It brings together in a convenient form a résumé of the methods that have been used by advanced workers. It will save much time formerly consumed by the necessity of fitting together the numerous articles appearing in scientific journals and advanced texts. For the worker who wishes to go beyond the pages of this book there is provided an ample bibliography at the end of each chapter. Here and there throughout the pages can be found suggestions and advice which will contribute to better publications.

To some, particularly the experienced, the treatment of the subject matter may appear tedious and tiresome. The author was not unaware of this possible criticism. Professor Snedecor justified his approach by his apparent belief that the novice, for whom the book was written, should begin on the first page rather than in the middle of the book. He handled his subject matter from a developmental viewpoint. In general, statistics is held to be a mode of thought or a point of view which must be synchronized with the biological, not something to be superficially attached to it.

An examination of the book, however, leaves one with the feeling that the author is too optimistic in his expectation that this work can be "readily understood by the lay reader." Although this text is one of the best yet written for beginners and will undoubtedly receive wide acceptance and welcome by entomologists, its mastery will require something more than casual reading. It will be "readily understood" only by the lay reader with a real desire to learn.

L. L. HUBER.—11-9-37.

Current Notes

WHITE ARSENATES FOR AGRICULTURAL INSECTICIDES TO BE COLORED PINK TO IDENTIFY THEM AS POISONS

With a view of preventing possible cases of poisoning, white arsenates, such as lead arsenate and calcium arsenate, which are universally used as agricultural insecticides, will be given a distinctive pink color, under a voluntary agreement of the producers of these chemicals, it was recently announced at the offices of the Manufacturing Chemists' Association, Washington, D. C.

This safety measure has been adopted after a five-year study and extensive tests to observe the results, which indicate that the change of color should provide a satisfactory safeguard against white arsenates being mistaken for materials for household or other uses.

Lead arsenate now being produced for the 1938 crop season is colored pink, while the color of calcium arsenate will also be changed from white to pink when present stocks of the insecticide are exhausted.

The United States Public Health Service, and medical and agricultural authorities commend the action of the manufacturers of agricultural arsenates.

CONFERENCE OF CONNECTICUT ENTOMOLOGISTS

The fourteenth annual conference of entomologists working in Connecticut was held in the Assembly Room at the Connecticut Agricultural Experiment Station, New Haven, Conn., on Thursday, October 28, 1937, beginning at 10 a.m. Dr. Philip Garman was elected chairman, and 109 persons were present. Luncheon was served by members of the entomology department staff.

The following program was fully carried out:

Greeting, DIRECTOR WM. L. SLATE, New Haven, Conn.

Some Entomological Features of 1937, W. E. BRITTON, New Haven, Conn.

Shade Tree Insect Developments in 1937, E. P. FELT and S. W. BROMLEY, Stamford, Conn.

The European Spruce Sawfly Situation in the United States in 1937 (lantern slides), H. J. MACALONEY, U.S.D.A., New Haven, Conn.

Preliminary Work with European Spruce Sawfly Parasites in the United States, P. B. DOWDEN, U.S.D.A., New Haven, Conn.

A Review of the Japanese Beetle Situation (lantern slides), C. H. HADLEY, U.S.D.A., Moorestown, N. J.

Report on the Federal Gypsy Moth and Brown-Tail Moth Work, A. F. BURGESS, U.S.D.A., Greenfield, Mass.

Recent Developments in Insecticidal Control of the European Corn Borer (lantern slides), C. H. BATCHELDER, U.S.D.A., and NEELY TURNER, New Haven, Conn.

Some Motion Picture Records of Connecticut Insects, PROF. A. L. MELANDER, New York, N. Y.

The Periodical Cicada; Occurrence of Brood XI in Connecticut in 1937 (lantern slides), PROF. J. A. MANTER, Storrs, Conn.

Notes Concerning Some of the Stalk Borers of Connecticut, HENRY BIRD, Rye, N. Y.

Some Observations on the Larval Instars of *Hylurgopinus* in Massachusetts, W. B. BECKER, Amherst, Mass.

Further Observations on the Control of the Apple Maggot and the European Red Mite (lantern slides), PHILIP GARMAN, New Haven, Conn.

Control of the Carpenter Ant in Telephone Poles (lantern slide), R. B. FRIEND, New Haven, Conn.

Damage to Houses by Powder-Post and Anobiid Beetles (lantern slides), NEELY TURNER, New Haven, Conn.

CORRECTION: Dr. S. W. Frost was by error announced to have become head of the department of entomology at Pennsylvania State College, according to information received in time for the October JOURNAL. Dr. E. H. Dusham is head of the department of zoology and entomology at the college, and Dr. Frost is in charge of the entomological work.

COTTON STATES BRANCH WILL HOLD THIRTEENTH ANNUAL MEETING IN NEW ORLEANS, FEBRUARY 3 TO 5, 1938

The Cotton States Branch will hold its thirteenth annual meeting in the Jung hotel at New Orleans, La., February 3 to 5, 1938. Oliver I. Snapp, secretary-treasurer of the Branch, requests that titles of papers for the program be mailed to him as soon as possible.

PROFESSOR P. J. PARROTT has been made director of the New York State Agricultural Experiment Station at Geneva, effective January 15, 1938, upon retirement of Dr. U. P. Hedrick, present director. Professor Parrott has been vice director of the station since 1928.—*Science* **86**:418. Nov. 5, 1937.

Horticultural Inspection Notes

THE FEDERAL domestic quarantine relating to the Mexican fruitfly was revised, effective October 15, to add a part of Jim Wells county, Tex., to the regulated area, to fix a host-free period from May 1 to August 31 of each year subject to modification, to add fruits of species of the genus *Sargentia* to the list of hosts, and to make other changes.

HERBARIUM specimens when dried, pressed and treated, and so labeled on the container were exempted from Japanese beetle certification in a revision of circular B.E.P.Q.-386, issued September 13, 1937, by the Bureau of Entomology and Plant Quarantine.

FEDERAL plant quarantine restrictions on the importation into the United State of frozen-pack fruits and their interstate movement from Hawaii and Puerto Rico, are covered in circular B.E.P.Q.-462 of the Bureau of Entomology and Plant Quarantine, dated September 15, 1937.

MISSISSIPPI placed a quarantine, on October 5, relating to the white-fringed beetle, *Naupactus leucoloma*, and Alabama and Florida have amended their quarantines to cover additional infested areas and to include cotton seed, lint, linters and gin trash in the wide list of products under restriction.

THE ARIZONA Commission of Agriculture and Horticulture has announced that the evergreen shrub *Euonymus japonica* will be accepted in Arizona when fumigated according to specifications, it appearing that the plant can be successfully fumigated so as to kill the red scale. The quarantine was accordingly amended on September 20.

THE CALIFORNIA quarantine relating to the alfalfa weevil was revised, effective September 16, modifying the area in Nebraska under quarantine, clarifying provision for entry of hay into the eastern mountain and foothill section of California, providing for year-round entry of alfalfa meal from approved mills, and eliminating restrictions on salt-grass packing hay from Utah.

CHANGES in the California quarantine relating to the vetch weevil, which became effective September 14, bring Georgia and South Carolina under regulation and increase the period during which vetch seed must be exposed to hydrocyanic gas fumigation from four to 24 hours.

THE ALABAMA quarantine relating to the sweet-potato weevil was revised, effective September 16, and amended on October 11, establishing certain sanitation requirements as to planting and digging sweet potatoes in Alabama, and requiring certification from other infested states. The area as extended comprises the entire states of Florida, Louisiana and Texas, four Georgia counties, nine Mississippi counties and parts of two Alabama counties.

THE OKLAHOMA embargo on Louisiana sweet potatoes and the plants was modified, according to a statement in a recent railway circular, to permit entry during the period from July 1 to January 30 under the provisions of the quarantine.

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